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ORIGINAL ARTICLES.

I.—Note on the Age and Locality of the *Estheriella*-Shales from the Malay Peninsula.

By R. Bullen Newton, F.G.S.

MR. JOHN B. SCRIVENOR, B.A., F.G.S., Geologist to the Federated Malay States, has forwarded to me for determination several pieces of a dark-greyish argillaceous shale, largely charged with particles of mica and valve-impressions of a small phyllopodous Crustacean, which he has discovered in the Native States of the Malay Peninsula.

In his letter Mr. Scrivenor remarks: "The fossils that I send were found by myself on the surfaces of a series of shales and sandstones, practically vertical and striking N.N.E.–S.S.W., at Pukus Semanggol, Larut, Perak. This series is of enormous extent; I have traced it over 180 miles north and south along the railway. So far no fossils whatever have been found in them, that I know of, in the Western States."

Before attempting to describe these fossils myself, I thought it desirable to submit them to Professor T. Rupert Jones, F.R.S., our principal authority on the fossil Phyllopoda; and he, fortunately for science, has taken so keen an interest in the specimens that he has carefully diagnosed their characters in a systematic description, and so made a valuable contribution to the palæontology of this little-known area of the Oriental region. Professor Rupert Jones' examination enables him to state that the shales contain only one form of this curious group of Crustaceans, which he refers to a new variety of an already described species from the Triassic rocks of Sicily known as *Estheria radiata* of Salinas. As the adult specimens exhibit radial as well as concentric sculpture, Professor Jones places this species under the generic name of *Estheriella*. From a stratigraphical point of view this determination is most satisfactory, as it furnishes additional evidence of the presence of the Trias formation in the Malay Peninsula, marine Triassic shells having already been reported by me from that country (Proc. Malacol. Soc. London, 1900, vol. iv, p. 130, pl. xii). It is interesting to note that the genus *Estheriella*, originally established by Weiss for species peculiar to the Bunter Sandstone of Dürrenberg, in Saxony, so far as can be ascertained, is only known to have existed in Triassic times.

II.—Note on a Triassic *Estheriella* from the Malay Peninsula.

By Professor T. Rupert Jones, F.R.S., F.G.S.

(PLATE II.)

Introduction.

NUMEROUS specimens (having the general aspect of *Estheria*) lie on the bed-planes of a bluish, slightly micaceous, non-calcareous shale from the "Shale and Sandstone Series" of the Federated Malay States. The valves lie flatwise in the strata, either singly or in still connected pairs; and are not so much compressed but that they show the concavity of the insides, and the convexity and special features of the outsides. There are many examples of valves in different stages of growth, but a striking similarity of character indicates that all belong to one species. The shell itself is absent, but hollow moulds of one valve and solid casts of the other supply material for defining its character. No other organisms have been recognized in the shale.

Description of the Species.

The valves (see Pl. II, Figs. 1–3) are broadly subovate, nearly semicircular, short, and broad or oval-oblong with rounded ends. The anterior extremity has the bolder curvature. The dorsal border is nearly straight; ventral border boldly curved. The umbo is towards the anterior end of the dorsal border, at about one-third of the length of the valve. Behind the umbo the border gently slopes to the postero-dorsal angle, and has a distinct but narrow marginal fold. The valve is of the same shape as fig. 19 in pl. iii, "Monograph of Fossil *Estheriæ*," Pal. Soc., 1862, p. 103, but with a more definite postero-dorsal angle; the short form, var. *subquadrata*, of the Wealden *Estheria elliptica* (4½ mm. long).

Many concentric parallel ribs or wrinkles, such as are observable in known *Estheriæ*, are shown by these Malayan specimens, both on the casts of the outsides and in those of the insides of the valves. In some respects, however, these concentrics of the Malayan species differ from those of almost all other Estherians, namely, (1) in being less ridge-like, broader, and more convex individually; (2) in having numerous small, subsidiary, parallel, raised lines, intercalated on their surfaces and in their interspaces; and (3) by being crossed with a radial ornament. The main concentrics or wrinkles are about fifteen in number, and are frequently seen to be pushed up into ridges near the umbo, as in specimen 'A,' Pl. II, Fig. 2, corresponding in its raised concentrics to the furrows in specimen 'B,' Pl. II, Fig. 1. At the umbo they are squeezed together, and indeed crushed down; but they are broader and rounded elsewhere. Throughout they are marked with the supplementary riblets (5 or 6) both on the regular costæ and others between them where there is interstitial space enough.

The Malayan specimens are characterized by having twenty-four and more delicate, close-set, parallel, linear furrows radiating from the umbo to the ventral edge of the valve. In some cases they are

more distinct on the anterior than on the posterior moiety of the valve, and sometimes more so on either than in the middle. In some valves, however, the radial lines are persistent throughout the ventral region, as, for instance, in the specimens shown by Figs. 2–4. A noticeable feature due to existence of these very thin radial sulci is that the surface of the adult shell has the aspect of having been squeezed transversely, and thus modified by the intervals between these slight (but sufficiently deep) furrows being puckered up into small, regular, parallel, radial ridges, crossed by the frequent successional edges of growth in the shell, and by the interstices of the concentric costæ. (See Fig. 4.)

Very fine delicate parallel lines are also recognizable on the radial ridges (see Fig. 4). The radial lines and ridges supply the generic characters of *Estheriella*, Weiss (Zeitsch. deutsch. Geol. Ges., vol. xxvi, 1875, p. 711, note; and R. Jones, Geol. Mag., 1891, p. 53).

Comparison of the Malayan with some Sicilian Species.

Some closely allied fossil species (presumably of Triassic age) have been figured as *Estheriæ* by Professors G. G. Gemmellaro [1] and E. Salinas,[2] to which these Malayan specimens have much resemblance. Professor Salinas gives full descriptions of the species he has figured.

Comparing the best of our specimens (Pl. II, Figs. 1–3) with Salinas' *Estheria radiata*, op. cit., pl. i, fig. 6, we see that they are rather larger, that the dorsal border is more strongly modified by the umbo, and has its two moieties more unequal than in Salinas' fig. 6; but it is nearly straight throughout, although slightly modified by the somewhat protruding umbo. Specimens 'A' and 'B' differ from *Estheria Ciofaloi*, Salinas, op. cit., pl. i, figs. 1–5 (especially figs. 1–3), in its shorter dorsal edge and less oblong outline. The subtrigonal aspect of figs. 2 and 3 may be due to a partial imbedment, such as occurs with numerous shells of a similar shape.

In the Malayan specimens we also find that the concentrics are broader, each bearing five or six costulæ; and that the radials are more numerous, thicker, and stronger; also that the Sicilian figures do not show any small intercalated concentrics, either on the broad ribs or in the interspaces.

Some of the above-mentioned differences in form are not of much importance; but on account of the numerous, thin, intercalated concentrics, and the radial lines occurring all over the ventral region (Pl. II, Figs. 1–4), I prefer to regard this form as somewhat different from Salinas' *Estheria radiata*, and to name it *Estheriella radiata* (Salinas), var. *multilineata*, nov.

An analogous structural aspect of the surface in a valve is shown by figs. 5–6 (particularly fig. 6*b*) in plate v of vol. ix of the Trans.

[1] G. G. Gemmellaro, "Sul Trias della regione occidentale della Sicilia": Atti Accad. Lincei, ser. III, vol. xii (1882), Rome (Memorie), pp. 451–473; pp. 455–456, *Estheria Ciofaloi*, Gemm. (not described), pl. v, fig. 13.

[2] Emmanuele Salinas: "Sulle Esterie del Trias di Sicilia," small 4to, Palermo (Museo Geol. Min. R. Univ. Palermo), 1897, pp. 1–12, pl. i.

Geol. Soc. Glasgow, 1890 (or 1891), described as that of the Carboniferous *Estheria tegulata*, Jones, at p. 84. In *E. tessellata*, an allied form (ibid., p. 82, pl. v, figs. 2–4), a similar arrangement is also shown of a concentric being crossed by a radial system of structural lines.

The Figs. 3*d–g*, Pl. XI, GEOL. MAG., 1897, pp. 289–293, might be regarded of special interest as showing how much the interstitial bar-ornament may be sometimes developed into superficial radials; but the intermediate stages are wanting. In *Estheriella* the radials certainly have the appearance of having been due to pressure at nearly a right angle to the vertical height of the valve, giving the sharp radials in Figs. 11 and 13 of Pl. II, GEOL. MAG., 1891. What may perhaps be looked upon as obscure traces of *radials* (regarded at the time of description as probably the remains of pressure wrinkles) are visible in the figure of *Estheria Greyi*, GEOL. MAG., 1878, Pl. III, Fig. 1. Better and more numerous specimens are wanted for further detailed examination.

EXPLANATION OF PLATE II.

FIG. 1.—Malayan specimen 'B.' *Estheriella radiata* (Salinas), var. *multilineata*, nov. A pair of valves, lying open, with the outer surface exposed. Magnified 3 diam.

,, 2.—Malayan specimen 'A.' The same species. A pair of valves, lying open and exposing the insides. Magnified 3 diam.

,, 3.—Malayan specimen '10.' The same species. Dextral valve. Magnified $\frac{3}{2}$ diam.

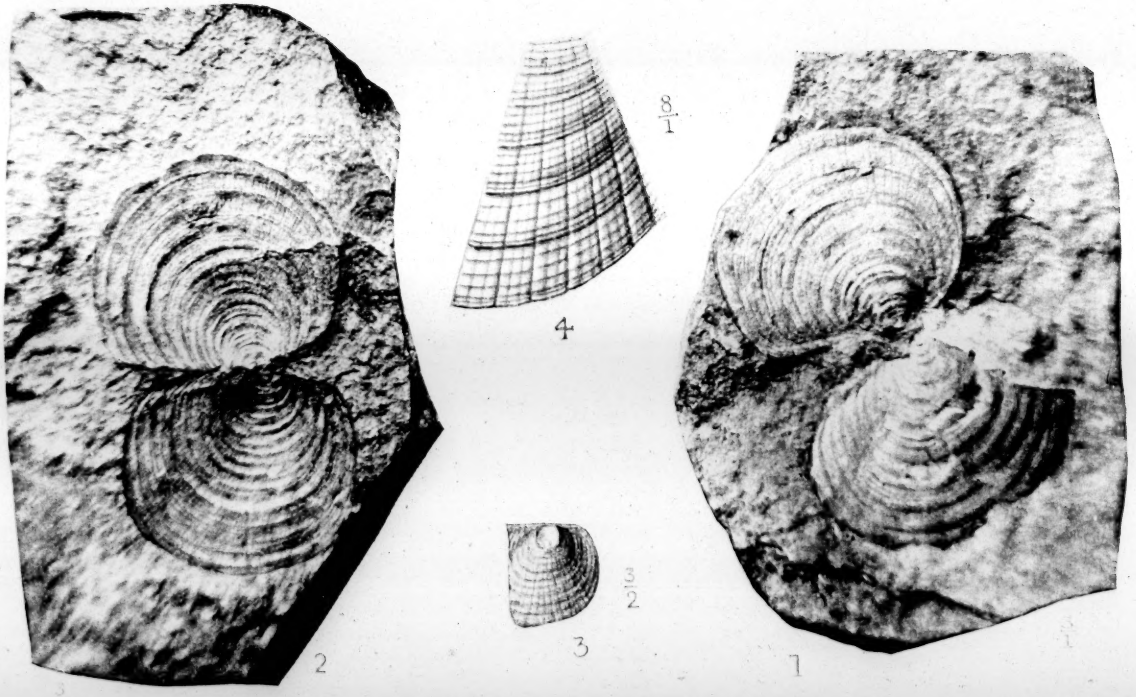
,, 4.—Malayan specimen '10.' The same species. Part of the surface of Fig. 3. Magnified 8 diam.

III. — NOTES ON SOME ROCKS FROM ARARAT.

By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S.

DURING a journey through Russian Armenia in 1893 Mr. H. F. B. Lynch ascended Ararat and collected a number of small specimens from that mountain and other parts of the country. These, after his return, he placed in my hands, requesting me to examine them. At that time he intended to include my report in a book then in preparation, which was completed after a second journey (through the Turkish provinces) in 1898.[1] On this occasion he was accompanied by Mr. Felix Oswald, B.Sc., who studied the geology of the country and collected numerous specimens. Mr. Lynch accordingly decided to omit from his work all geological details, and leave these to be dealt with separately by Mr. Oswald. But some time must still elapse, owing to the pressure of official duties, before he will have completed the work, and as they did not, on the second journey, go near Ararat, I have decided, since the mountain has so much historic interest, to publish my notes, though a little has already appeared on this subject. Herr H. Abich, to whose unwearied labours we are so greatly

[1] "Armenia: Travels and Studies." 2 vols. Longmans, 1901. The ascent of Ararat is described in chs. xi–xiii (vol. i).



Triassic *Estheriella* from the Malay Peninsula.

indebted for information about the geology of Asia Minor, ascended Ararat on July 29, 1845,[1] and Dr. F. Becke[2] has described the microscopic structure of three specimens which he brought down. One is from the summit, another from a parasitic cone, Takjaltu, on the south-east slope, and a third from the same slope of Little Ararat. Mr. Lynch's collection, as will be seen, is a much larger one, so that it gives a more complete idea of the materials of the mountain.

The volcanic mass of Ararat, a natural monument to mark the place where three empires meet, rises at one end of the Aghri Dagh range from a rudely elliptical base measuring about 28 miles from N.W. to S.E. by 23 miles in the transverse direction. The mountain viewed from the north, where it is seen towering up to some 14,000 feet above the Araxes valley, shows a long ridge, its eastern end crowned by the fairly steep cone of Little Ararat (12,840 feet), from which it descends to about 9,000 feet, and then rises, at first gently, afterwards more sharply, to the snowy pyramid of Great Ararat (16,916 feet).[3] On its northern side a chasm or glen runs up towards the summit into the heart of the mountain. This also was visited by Mr. Lynch, who informs us that in 1840 it was to some extent modified by an earthquake.

Great Ararat.

In his ascent of Ararat he encamped first at a height of about 7,500 feet in an upland valley on the northern side of the depression (about 8,800 feet) between Little and Great Ararat, and for the second night on the south-eastern side of the latter, at an elevation of 12,194 feet. A specimen marked Great Ararat Camp (A) is a dark-grey rock containing numerous whitish felspar crystals (up to about 0·1 inch in diameter) and some minute vesicles. Microscopic examination shows a base consisting of a light-brown glass crowded with minute prismatic microliths and speckled with opacite. In this ground-mass are scattered grains of hematite or magnetite and crystals of plagioclase felspar.[4] The latter frequently contain numerous glass enclosures with vacuoles, which not seldom are crowded in an outer zone of the crystals. Pyroxene also occurs, and although the grains of it have a general resemblance, there is probably more than one species present. Some exhibit slight pleochroism and straight extinction, indicating a mineral akin to

[1] For early ascents of Ararat, see Alpine Journal, vol. viii, p. 213.

[2] H. Abich: "Geologische Forschungen in den kaukasischen Ländern," iii, 102. A general description of the chief varieties is given by Dr. Parrot, who made the first ascent in 1829 ("Journey to Ararat," p. 198, N.D.).

[3] This is the height given by Mr. Lynch; other authorities make it 17,100 feet. The snow-line in Summer is about 13,500 feet.

[4] I prefer to leave this indefinite name in all these rock-specimens. Many of the crystals are not fitted for measurement by reason of enclosures, etc. Others give indefinite results, but in most of the specimens I have identified labradorite, and more than one species is present, the microliths agreeing better with oligoclase. I have thought it needless to note the variations in size. The largest (in B, *b*, 1) is about ·08 inch long, but they commonly range from about ·06 inch downwards, the pyroxenes running a little smaller.

amblystegite, while in others the extinction angle varies, being once or twice large enough for augite.

"Below the summit of Great Ararat (B)." Twenty-eight rock fragments, some of them very small, were collected just below the summit[1] of Great Ararat, at about 16,700 feet. They vary much in colour and aspect, but probably include only three or four varieties.

One group (B, *a*) appears to be represented in its freshest condition by a dark-grey rock resembling that already described, and the microscope shows no great difference. The glassy base is a little more ferrite-stained and has fewer distinct transparent microliths; the plagioclase felspars have fewer and smaller glass enclosures; the pyroxenes are similar, one or two being certainly augite.

A second group (B, *b*, 2) is represented in its freshest state by a slightly darker, more porous, more porphyritic rock. A slice of it shows a larger amount of glass than the others, this being of a rich brown colour with granules of opacite and a fair number of transparent microliths. In it we find grains of iron-oxide (hematite in part); plagioclase felspars, generally idiomorphic, occasionally with rather abundant glass enclosures in the larger specimens (probably from partial melting), and a light-brownish pyroxene, some crystals of it certainly augite, perhaps one or two amblystegite.

Three specimens (B, *b*, 1) of a blackish glassy material studded with small crystals of white felspar. The specific gravity of one specimen is 2·483.[2] A slice cut from one of the specimens shows a glass which exhibits a fluxional structure and is present in larger amount than in any of the other rocks. It is generally brown, but with almost colourless streaks, is studded with microliths, both minute belonites and small prisms apparently of felspar, and is slightly spotted with granules of iron-oxide. In this base are crystals, sharp-edged, broken, or rounded, of plagioclase felspar, magnetite, or hematite, hornblende and amblystegite. Glass enclosures in the felspar are small in size and variable in amount, in several cases developed mostly in the exterior zone. The rock is a pitchstone (andesite).

A number of light-coloured fragments (B, 6) varying from yellowish-grey to almost white, the differences probably being due to the amount of decomposition. A specimen sliced shows the rock to be less well preserved than the others, but its differences are only varietal. It also contains amblystegite.

The description of Herr Abich's specimen, said to come from the summit of Great Ararat (on which no rock was exposed when Mr. Lynch reached it), agrees so closely with that given above under B, *b*, 1, that I have little doubt the rocks are substantially identical. His specimen contains a rhombic pyroxene which Dr. Becke names bronzite, but which I think would now be regarded

[1] The highest rock visible at the time of Mr. Lynch's visit.
[2] Determined by Walker's balance.

as amblystegite, and a green non-pleochroic augite instead of the fairly pleochroic (brownish-green) hornblende.

The specimen from the Takjaltu, a parasitic cone on the south-east slope of Ararat, must have come from the main pyramid not very far from Mr. Lynch's line of ascent. It is "a pale grey compact porphyritic rock, with plagioclastic felspar and a little sanidine, glass enclosures being frequent, sometimes forming a kind of network. A pale green, almost colourless augite is rather rare, with remnants of a strongly pleochroic hornblende (*a* pale yellow, *b* red-brown, *c* brown-red) and a pale green, almost colourless bronzite more abundant than either."[1]

A specimen from the south-east side of Little Ararat is a porous bronzite-augite andesite, in which Dr. Becke recognises oligoclase or andesine, rich in glass inclusions, magnetite, a green augite, and 'bronzite' in long thin prisms up to ·06 inch.

Chasm of Arguri (Great Ararat).

Three are labelled as "typical stones." Two of these (C) are yellowish-brown fragments, obviously rotten lava. The third (D) is a compact darkish-grey rock, speckled with lightish-grey. A slice of this exhibits only varietal differences from some of those already described; the base is nearly that of the specimen A. There are crystals of felspar and of pyroxene as before, though the former are not quite so large as usual.

Of the other rocks (E) from Arguri, three appear to be consolidated andesitic ash or fine breccia; three are lavas in a very decomposed condition; one is a slightly porous reddish rock, with small crystals of glassy felspar, probably allied to some of the varieties already described; and another is a similar rock of a more glassy aspect and deeper red colour, both the felspars and the glass intervals being slightly larger. A slice from the last shows the actual glass to be fairly clear, but it is studded with very minute, slightly brown microliths, and contains a large number of rodlets of iron-oxide. It exhibits a fluxional structure. The porphyritic minerals call for no special remark except that the rock is rather deficient in pyroxenic constituents.

Little Ararat.

Two rocks[2] (F), one evidently a grey andesite similar to those already described, the other pinker in tint, probably much the same kind but rather decomposed; it may be this rock which gives the peak its dominant violet hue. Microscopic examination shows the former to be a pyroxene-andesite with only insignificant varietal differences from the grey rocks already described. Pyroxene is not very abundant, but among it is augite, perhaps also amblystegite.

A third specimen (G) is a rock of generally similar structure, but of more brick-red colour. (It is stated to give a pinker tinge to some parts of the peak.) This exhibits some slight differences under

[1] A condensed translation of the original description.

[2] Said to be typical of the dominant rock of the peak.

the microscope. Its base is a sienna-brown glass, containing numerous felspar microliths, with some grains of hematite, perhaps also of pyroxene. In this are plagioclase felspars, much as usual, and some pyroxene crystals, most of which appear to be augite.

Other Rocks from Little Ararat.

Three specimens (H). One is a slightly porous, dark rock, with small crystals of lighter-coloured felspar; another a similar rock, but a little more porous, and the felspar slightly less conspicuous; both these weather an Indian-red colour, and the latter is slightly streaked with that tint. A third rock is a piece of vesicular scoria of a purplish-brown colour, weathering red. The microscope shows the base of the first specimen to be a rather light-brown glass (containing numerous acicular microliths and grains of opacite) in which are scattered many felspar crystals of various sizes, up to about 0·11 inch, the larger not unfrequently broken and sometimes full of glass enclosures. There is also some augite, distinct amblystegite, and iron-oxide. The larger minerals are pretty clearly of a distinctly earlier date than the final consolidation of the rock. The second specimen shows only varietal differences from the other one; the glass is rather browner, the felspar crystals do not run quite so large, and augite distinctly predominates over amblystegite. The arrangement of the glass enclosures in some of the felspars suggests that they have been produced by a local melting down rather than by inclusions of magma. The ground of the red streaks under the microscope is a richer red, more like that of G. These two rocks most resemble B, *b*, 2.

General Remarks.

So far as we can infer from these specimens, the rocks of Ararat, considering its size, exhibit surprisingly slight differences. They are augite-andesites, varying slightly in the nature of the glassy base, the size of the felspars, the occasional presence of a hornblende, and the amount of amblystegite, which mineral, however, probably is rarely quite absent. The larger felspars are sometimes corroded or broken, and not unfrequently an outer zone may be distinguished, by either containing more enclosures, or being more free from them, or extinguishing at a slightly different angle. The enclosures apparently are of five types — (*a*) small separate microliths or mineral granules, in some cases possibly a pyroxene, (*b*) very minute belonites, associated in clouds, (*c*) minute dust, (*d*) brownish glass, (*e*) cavities. Where one or more is conspicuous this is noticed above, and I am disposed to regard the glass enclosures as more often results of partial and local melting in a crystal owing to irregularities of chemical composition than to enclosures of the original magma.

Aghri Dagh.

This name is applied to the range of which Ararat forms the eastern bastion, and sometimes even to that mountain. It is nearly 100 miles in extent, its peaks rising in one case to more than

11,000 feet above sea-level, and its passes 7,000 to 8,500 feet.[1] It was crossed by a pass south of Kars (slightly to the west), from some part of which these specimens must have come (see vol. i, ch. xx). The rocks are said to be granite, diabase, etc.

A fairly coarse gneissoid rock (L, 2) is composed of quartz, pale pinkish buff felspar, and a green mineral. Under the microscope it is seen to consist of quartz, felspar (plagioclase apparently predominating), and a green chlorite. The rock, on examination with crossed nicols, seems to have been much modified by pressure, although now it is completely cemented. The larger grains of quartz have a fragmental aspect, and much of the mineral proves to be a mosaic of small grains, with a slightly streaky arrangement. The felspar has the same aspect, and some of the crystals are breaking up into a mosaic of small granular felspars with a few flakes of white mica, the latter occurring elsewhere in the slide, though sparingly. The green mineral is apparently a chlorite, and there are also two small garnets and one or two zircons. From its general aspect I should consider the rock to be very old, as considerable mineral changes have occurred since it was acted upon by pressure.

Two specimens of a compact dull reddish-purple rock. It is found, under the microscope, to consist of long microlithic crystals of plagioclase felspar imbedded in a ferrite-stained base, and is not in a good state of preservation. Probably it comes near to the basalts, and formerly would have been called a melaphyre. The specific gravity is 2·709. A veined specimen appears, from the label, to be connected with this, though the rock itself is greener in colour, more like the next in order. The vein chiefly consists of calcite and epidote, with some iron staining.

A compact dull green rock (K), slightly veined with calcite, which forms jagged ridges, between Kagizman and Karakilisa, running like walls from north to south. Under the microscope it is found chiefly to consist of two minerals, the most abundant, green, probably a hornblende; the other, clear and colourless, most likely replacing a felspar. Iron-oxides and some small sphenes are present. The rock may be named a diabase, probably forming dykes.

Mr. Lynch brought back about a dozen specimens representing rocks which had attracted his notice during the rest of his journey, the majority being limestones from the neighbourhood of Lake Van. But as he returned to this district during his second journey, I have transferred my description of them to Mr. Oswald, with the exception of two specimens of a serpentine which my interest in that rock induces me to publish. One, with the label "On the road behind Akhtamar (Lake Van)," is a dark-green serpentine with some lighter streaks and with oblique slickensided surfaces, sometimes partially coated with cream-coloured or green steatite, giving to the specimen a rather lenticular form. Under the microscope the

[1] See Lynch, "Armenia," vol. i, p. 414 et seq., and vol. ii, p. 384.

serpentine indicates severe crushing (the flaky minerals often resembling antigorite), and contains a few much altered bastite crystals and powdered magnetite, more or less in streaks. It must originally have been a Saxonite, and in its present condition could be matched from several parts of the Alps. The other is labelled "Erzerum–Trebizond. Gorge beyond Pirnakapan. Kop Dagh."[1] It is a dark rock with an external steatitic film, generally greenish-white, but assuming a blue tinge where very thin. The specific gravity is 2·72. Microscopic examination shows it to consist of olivine partially changed into serpentine, bastite, in parts replaced by a mineral with slightly oblique extinction (? tremolite) or a minute fibrous one transverse to and obliterating the cleavages, magnetite in grains and occasionally in a powder (perhaps the latter sometimes hematite). The olivine is less altered than the bastite, for the former in most parts is only in the first stage of change, thin strings of serpentine occupying the cracks. Thus the rock is a partially serpentinized Saxonite not materially affected by pressure.

IV.—On the Age of the Gebel Ahmar Sands and Sandstone, the Petrified Forest, and the Associated Lavas between Cairo and Suez.

By T. Barron, A.R.C.S., F.G.S.

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THE geological age of these beds has been the subject of much speculation by various geologists. In 1845 Orlebar[2] claimed to have found the Gebel Ahmar Sandstone at No. 3 Station on the Old Post Road to Suez, overlying Miocene beds containing *Scutella Zitteli*. O. Fraas[3] in 1867 imagined he could trace a graduai passage between the Upper Moqattam and these beds, and concluded, therefore, that they were of marine origin and Lower Oligocene age, as they had undergone the same general earth-movements as the Eocene beds.

Dr. Schweinfurth,[4] discussing the age and origin of these beds, says that there are two reasons for concluding that they are not marine: (1) they occur at different levels in various localities, and (2) they rest on a very uneven surface which does not differ much from the present-day relief. He, in fact, considers that the present-day relief of the surface had already been inaugurated before these beds were laid down. He also calls attention to the resemblance existing between the Pliocene sands in the Nile Valley and these beds, and finally groups them together in his map as (?) Pliocene.

[1] Lynch: "Armenia," vol. ii, p. 229.

[2] "Some observations on the Geology of the District between Cairo and Suez": Journ. Roy. Asiatic Soc., 1845.

[3] "Aus dem Orient," 1867, pp. 157–8.

[4] "Geol. Schichtengliederung d. Mokattam": Zeitschr. d. Deutsch. Geol. Gesells., 1883, p. 719 et seq.

Discussing O. Fraas's views, he objects to the theory of a gradual passage from the Upper Moqattam into Gebel Ahmar beds, because there is no evidence of limestone and clay in the latter, and further that they have no affinity with the Moqattam beds, but closely resemble the Pliocene sands at the foot of the Moqattam. He found also on examining them that they did not overlie the uppermost beds of the Upper Moqattam, but in different places overlaid different beds at varying levels. This to Dr. Schweinfurth's mind was a proof of the fresh-water character of the deposit.

After discussing the evidence for and against the idea that the trees in the Petrified Forest have been silicified *in sitû*, he concludes that they have in all probability been transported to where they now lie, and subsequently petrified. The reasons adduced are as follows :—

1. All the trunks are horizontal; Figari Bey alone is reported to have found one erect.
2. No bark has been observed on the trunks, therefore they have not been silicified before being decomposed.
3. Many trunks appear to have been enclosed in the sand after silicification.
4. No branches or roots have been found in the district near Cairo.
5. Stems have been found with only nodes on them.

This author points out that there is an absence of stratification in the beds, and concludes that petrification must have taken place in a series of basins, because of the difference of level between the places at which the trees are found.

Professor Sickenberger [1] considered the Gebel Ahmar beds to be of Miocene age. Professor Mayer-Eymar [2] says that after the Lower Tongrian sea had retired and the volcanoes had become extinct, the country became covered by dense forests of trees for the most part of the order Sterculiaceæ and the species *Nicolia Ægyptiaca*, Unger. Then the subterranean waters, arrested either by the Senonian fold of Ataqa-Abu Roash or by internal volcanic masses, and heated by the latter, burst out to the right and left below the river of that period, and in the form of warm silicious springs bathed the foot of the trees wherever there was any depression. The trees were thus silicified *in sitû*. According to this author the age of the Petrified Forest is later than that of the basalt. He is of opinion that Gebel Ahmar is not the product of geyser action, that geysers did not exist, and that the various peaks of quartzite are in each case the product of a strong thermal spring.

M. Fourtau [3] regards Gebel Ahmar and Kreibun as the product of true geysers, and assigns them and the Petrified Forest to the Pliocene period.

Dr. Blanckenhorn [4] considers that geysers such as those of

[1] Three lectures on the Geology of Egypt, 1891.
[2] Bull. de l'Institut Egyptien, 1893, pp. 393 et seq.
[3] "Etude géol. sur le Gebel Ahmar" (l'Institut Egyptien, Decembre, 1894); and "L'age des Forêts pétrifiées des déserts d'Egypte" (Bull. Soc. Khéd. Géographie, sér. v, No. 2, 1898).
[4] "Das Oligocän": Zeitschr. d. geolog. Gesells., 1900, pp. 477 and 478.

Yellowstone Park were not necessary to the formation of Gebel Ahmar Sandstone; hot springs were capable of doing all that is required. He imagines dunes and marshes, fresh-water basins or lagoons containing silica, and sand which was borne by fluviatile or æolian agencies and disposed in an irregular manner in the neighbourhood of the springs. This was cemented together by the silica contained in the water. This author regards the Gebel Ahmar Sandstone as Oligocene, while the silicified forests he makes Lower Miocene in many places.

It is now necessary to give the views of the present writer regarding the age of the beds in question. In the neighbourhood of Cairo there exists an area covered with petrified trunks of trees which is known as the Petrified Forest. These tree-trunks, now lying on the surface, have been exposed by the removal of the sands, etc., in which they were originally embedded. There is no evidence for the idea that these trees were silicified *in situ*; there is little doubt that they have been carried thither by a river and deposited in an estuary or lagoon.

The beds in question, if traced northwards, can be seen to disappear under the thin sheet of basalt underlying the Lower Miocene beds. This is the case in every place in this district where these two formations are seen in contact.

As a proof that the silicification of the tree-trunks did not take place at the time they were deposited, one may point to the entire absence of bark in every instance, the complete lack of remains of leaves and branches, and in many instances the marks of decomposition in the trunks which must have taken place prior to silicification. Another proof is the fact that the thermal springs were subsequent to the outpouring of the basalt. Evidence of this is seen in Gebel Gafeisad or Agleiat Qamr (a volcanic neck), where the hard plug of silica filling up the throat of an old thermal spring stands right in the centre of what was the neck of the volcano. From this radiate hard veins of silicious rock which are the infilling of fissures out of which welled the warm silicated waters which did the work of petrification.

North of Dêr el Bêda, the ruined palace of one of the Pashas, there occurs another volcanic neck, with a large dyke-like mass of quartzite running through it, which is undoubtedly the result of the plugging up by sand and colloid silica of a fissure up which the silicated waters rose. Round these two places numerous examples of plugged fissures are seen, while a certain area of the sand around has also been consolidated.

To the north-east of Bir Gendali and about 10 kilometres down Wadi Gendali there occurs what appears to be an injected fissure out of which basalt issued at one time. Connected with this, and standing out in relief, is the plug of a geyser or very large thermal spring opening. Here the relations between the basalt and the silicious rock are the same as those observed at the other places above mentioned, that is to say, the basalt was prior to the formation of the silicious plugs. It is interesting also to notice that in the

neighbourhood of volcanic vents these injected fissures or plugs of thermal springs are much more numerous. It is also significant that only in the neighbourhood of these thermal fissures does silicified wood occur in abundance.

In the foregoing paragraphs it has been indicated that the order of succession of the beds in question is, first, the floating in and depositing of the trees in a shallow estuary or lagoon; second, the pouring out of the basalt; and third, the breaking out of thermal springs containing silica in solution which petrified the trees in the sands. It might be maintained that the order of succession is not clearly proved between the basalt and the thermal springs. To this the answer is that it would be impossible for a geyser to coexist with an active volcano, and that if it were prior to the volcano the silica deposited by it would have been dissolved and absorbed by the igneous rock.

The history of these beds appears to be as follows:—After the deposition of the sands, etc., containing the trees, a series of earth-movements took place which culminated in an outburst of basalt on both sides of the present Nile Valley. When the force of the outburst had expended itself, the volcanoes, which had not (as far as one can see between Cairo and Suez) poured out very thick sheets of lava, became quiescent, earth-movements continued which threw the rocks into shallow basins, fractured the volcanic necks, and eventually opened a way for the outpouring of heated silicated waters. These waters issued sometimes undoubtedly in the form of a geyser, although in the majority of cases they came out in the form of hot springs. Over the surface of the basalt they flowed, penetrating the cracks and filling them with chalcedonic silica, many of these infillings being now seen standing out in relief on the surface of the decomposed basalt. The silicated waters gradually filled up the basins, and in process of time the trees which had already begun to decay in the loose sands in which they were lying, became silicified in the form in which they are now found.

Various writers have asserted that there were thermal springs during Lower Miocene times, but there is no evidence for this. The remains of plugged fissures are seen sticking up in Lower Miocene deposits, but the fact that no alteration of those beds is discernible, while in every instance where they occur in the Oligocene the sands are consolidated round them, to the writer's mind effectually disposes of this contention. Dr. Blanckenhorn[1] makes the age of the basalt on the east side of the Nile Valley to be Lower Miocene, while he assigns an Oligocene age to most of the silicified wood. The evidence is all the other way, and the onus of proof rests with him. As has been shown in a recent paper by the writer,[2] this basalt underlies in a discordant manner beds of Lower Miocene age, and it is therefore plain that the age of this lava is older than Lower

[1] Loc. cit.
[2] Geol. Mag., 1904, pp. 603–608.

Miocene. Nor is it likely that a basalt outburst on one side of the Nile Valley should be of Lower Oligocene age, while a similar flow of lava on the other side is of Lower Miocene age, yet this is what Dr. Blanckenhorn states in his work previously quoted.

From what has been said, however, it would appear that a definite sequence of events has been established, and the following summary may now be made of the conclusions arrived at by the writer.

1. The Petrified Forest has not been silicified *in situ*; the trees have been brought from a distance by a river and deposited in a shallow lagoon or estuary.

2. The trees were not silicified immediately on deposition; they lay embedded in the sands for some time and underwent some decomposition, as is witnessed by the total absence of bark, branches, and leaves, and by the irregular and pitted exterior of the trunks, which must represent the external condition of the trees when the petrifying waters reached them.

3. After the deposition of the sands in which the trees were embedded had practically ceased, there was an outbreak of basalt which covered a good part of the beds.

4. After the volcanic action had ceased, earth-movements produced fissures up which warm silicated waters rose in the form of geysers and hot springs. The volcanic necks were fractured, and eventually the fissures thus produced were filled up by plugs of quartzite or chalcedonic silica, the surrounding rocks were thrown into shallow basins by two sets of folds, and the silicated water which collected in these basins silicified the trees lying in the sands.

5. When the geysers and hot springs had died out, a good deal of denudation took place; the hard plugs representing the throats of the springs were left standing out in relief; and when the Lower Miocene sea (first Mediterranean) invaded this district from the north-west, it deposited its sediments round these stumps and produced the appearance which has led some observers to the conclusion that the geysers occurred at that period.

6. The age of the Petrified Forest, the Gebel Ahmar Sands and Sandstone, and the associated lava-flows, is undoubtedly Oligocene, as these deposits fall between Eocene and Lower Miocene beds.

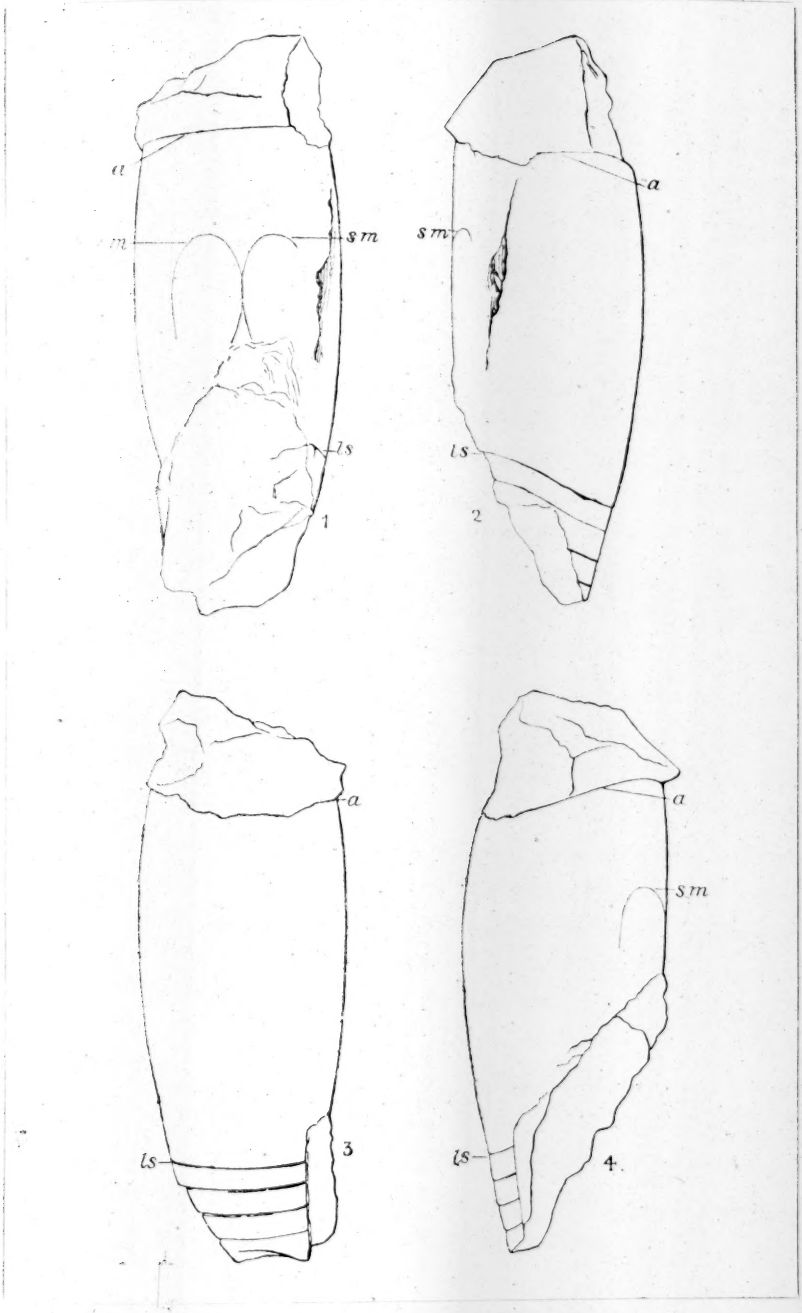
V.—On a specimen of *Cyrtoceras* (*Meloceras*) *apicale* from the Carboniferous Limestone, Kniveton, Derbyshire.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

(PLATE III.)

THE specimen which forms the subject of the present communication is a fragment of a Nautiloid in the collection of Dr. Wheelton Hind, F.G.S., from the Carboniferous Limestone, Kniveton, Derbyshire, that seems to be referable to *Cyrtoceras* (*Meloceras*) *apicale*. This species, instituted by Dr. Foord in 1898,[1]

[1] Monograph of the Carboniferous Cephalopoda of Ireland (Palæontographical Society), pt. ii, 1898, pp. 33–36, pl. xi, figs. 1*a*, 1*b*, 2*a*, 2*b*, 3; pl. xii.



Cyrtoceras (Meloceras) apicale, A. H. Foord.

Carboniferous Limestone : Kniveton, Derbyshire.

and based upon examples from St. Doulagh's, co. Dublin, Ireland, was characterized as follows:—

"Shell of moderate size, rather sharply curved in the lower third of the septate portion, but becoming almost straight above this, so that a fragment consisting only of the upper two-thirds of the shell would scarcely exhibit any curvature. Upon a chord of 38 mm. subtending the concave side of the apical region of the shell the greatest curvature is 5 mm. The rate of tapering above this curved part is about 1:4, which is a rapid increase in diameter. The section is very nearly circular, the siphuncle close to the margin of the outer curvature of the shell. The body-chamber considerably exceeds one-third of the length of the entire shell; its basal line is indicated by the letters *a*, *b*, in fig. 2 of pl. xii, in which its obliquity is very marked, making an angle with the horizontal axis of the shell of about 18°. The septa are numerous, and being tilted up in a ventro-dorsal direction the sutures have a strong obliquity on the sides of the shell, while they are nearly horizontal on the ventral and dorsal aspects, perhaps with a slight arching upwards on the dorsal aspect (pl. xii, figs. 1*a*, 1*b*). The distance between the sutures in an adult shell (pl. xii, fig. 1*b*), where the diameter is about 50 mm., is from 5 to 6 mm.; in a somewhat smaller example (pl. xii, fig. 3) the sutures are 4 mm. apart where the diameter is 15 mm., 6 mm. apart where it is 37 mm. In a smaller specimen (pl. xi, figs. 2*a*, 2*b*), which is entirely septate, there are twenty-two septa within a distance of 106 mm. The chambers must thus have been very shallow. Exactly in the median line of the ventral aspect, or outer curvature of the shell, there is a straight thread-like line or keel, feebly developed, but clearly perceptible when the surface of the cast has not been abraded; it is represented rather too broad in the figure (pl. xii, fig. 1*b*). The siphuncle is exogastric—that is, it is situated close to the convex or ventral border of the shell; it is strongly inflated in passing through the chambers (pl. xii, figs. 3, 4*a*, 4*b*), casts of it presenting the characteristic bead-like appearance as in the last figures referred to.

"The surface of the shell is perfectly smooth.

"The approximate measurements of the most complete specimen give length 190 mm., greatest diameter of body-chamber 53 mm., diminishing to 48 mm. at or close to the aperture, and 6 mm. near the apical extremity."

The specimen in Dr. Wheelton Hind's collection from Kniveton consists of the internal cast of the greater part of the body-chamber, and of the ventral portion of the four preceding chambers (see Plate III, Figs. 1–4, p. 63). The body-chamber has a mean length of 73 mm., and is slightly curved; it attains its greatest diameter at about one-third of its length from the aperture, the ventro-dorsal and transverse diameters here being 43 and 44 mm. respectively; it gradually tapers both towards the aperture, where its ventro-dorsal and transverse diameters are 40 and 42 mm. respectively, and towards the base of the body-chamber, which is imperfect dorsally but has a transverse diameter of 34 mm. Part of the aperture is

preserved; this appears to have been simple and nearly parallel to the base of the body-chamber. The septa are oblique, tilted up on the dorsal side; the chambers are shallow, the sutures being about 5 mm. apart at the middle of the ventral aspect, or outer curvature of the shell. There is no thread-like line or keel in the centre of the ventral aspect. The siphuncle is not clearly shown; it seems to have been inflated between the septa and to have been exogastric, i.e., situated near the ventral surface of the shell. The test is not preserved.

The characters of the specimen agree so closely with Foord's *Cyrtoceras* (*Meloceras*) *apicale* that I think it may be correctly referred to that species. Hitherto the species has been recorded only from the Carboniferous Limestone of St. Doulagh's, co. Dublin.[1] Dr. Hind's fossil is interesting, therefore, as showing the occurrence of the species in this country also. It possesses additional interest from the fact that it partially exhibits the form of the muscular attachment of the animal to its shell. In the middle of the less convex (or dorsal) surface of the body-chamber there are portions of two elliptical longitudinally-elongated areas,[2] each about 18 mm. wide; they touch each other in the median line of the ventral surface at a point 33 mm. below the edge of the aperture, part of which is also well shown in this fossil. Their anterior borders are 23 mm. from the edge of the aperture; both areas are imperfect posteriorly owing to the imperfection of the specimen, and for the same reason their exact position with reference to the last septum is not indicated, but it is estimated that the point at which these two elliptical areas meet was about 23 mm. in advance of the last septum, their anterior borders being about 10 mm. nearer the margin of the aperture. These elliptical areas are evidently the impressions (on the natural internal cast) of the muscle-scars that existed on the internal surface of the dorsal portion of the shell. The condition of the surface of the specimen prevents us from recognising any indication whatever of the band connecting these two areas across the ventral surface. They are exactly comparable with the muscle-scars previously described in the genus *Amphoreopsis*.[3]

EXPLANATION OF PLATE III.

Cyrtoceras (*Meloceras*) *apicale*, A. H. Foord.

FIG. 1.—Dorsal aspect, exhibiting portion of peristome or margin of aperture (*a*), and part of the boundaries of the two muscle-scars (*sm*), *ls* being (in all the figures) the last septum or base of the body-chamber.

,, 2.—Right lateral aspect, showing part of the peristome (*a*) and a small portion of the boundary of the right muscle-scar (*sm*).

,, 3.—Ventral aspect, showing a portion of the margin of the aperture (*a*).

,, 4.—Left lateral aspect, displaying part of the margin of the aperture (*a*) and the boundary of the left muscle-scar (*sm*).

Carboniferous Limestone: Kniveton, Derbyshire.

In the collection of Dr. Wheelton Hind, F.G.S. All the figures are drawn of about three-fifths the natural size.

[1] A. H. Foord: Mon. Carb. Ceph. Ireland (Pal. Soc.), pt. ii, 1898, p. 36.

[2] A portion of the boundary of each area is indicated by a very obscure feebly-impressed line.

[3] G. C. Crick: Proc. Malac. Soc., vol. vi, pt. 3, Sept. 1904, pp. 134–7, pl. viii.

VI.—On a new Tortoise from the Lower Headon Beds of Hordwell, *Nicoria headonensis*, sp. nov.

By Reginald W. Hooley, F.G.S.

THE bones of the carapace and plastron from which this species has been determined were discovered in a thin seam of grey sand intercalated in the Mammalian band of the Lower Headon Beds at Hordwell, Hampshire. They were lying scattered over an area of about four feet. The broken edge of the entoplastral and right hyoplastral were sticking out of the cliff face. The sea had carried away the missing portions of these bones and probably those lost of the carapace and plastron.

The illustration is from a photograph of an attempted restoration in plaster. The discovered bones are shaded, and from these the missing plates can easily be restored; the portion of the carapace anterior to the second neural is alone doubtful.

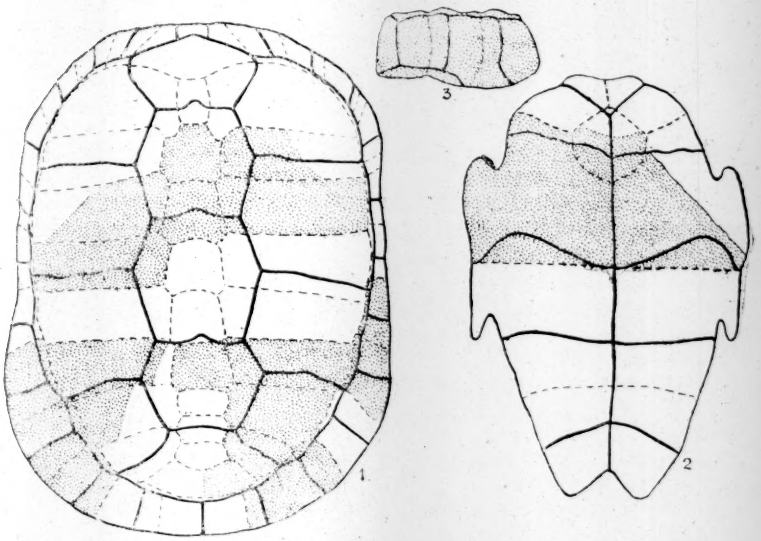
Of the plastron the character of the hyoplastrals is of course clear, and the remainder worked out from its nearest allies. The carapace, were it not for its posterior broadening, would be very ovoid; indeed, the line of the costal and marginal suture is quite ovate. It probably measured 19 mm. in length. It is well vaulted, with a slight depression posteriorly where it becomes expanded. There is no discernible carination, and the marginals are not serrated.

Of the carapace, the bones found consist of the second, third, and sixth neurals, and the right half of the second supra-pygal. The proximal end of the second, the whole of the third, sixth, seventh, and eighth costals of the right, a piece of the third, the entire fourth and sixth, and the distal end of the seventh costal of the left. The seventh, eighth, tenth, and eleventh marginals of the right, and the fourth, fifth, sixth, eighth, ninth, and tenth of the left. Of the plastron, the greater portion of the entoplastral, a small moiety of the anterior end alone being destroyed. A part of the right hyoplastral and the whole of the left.

The neurals have their short sides placed posteriorly. The second is octagonal and the third and sixth hexagonal, and judging from the proximal ends of the neighbouring costals the fourth and fifth are hexagonal and also symmetrical with the third and sixth. The surfaces of the second neural sutures with the first costals are not on a plane, but concave, the left showing a greater depression than the right, but this is doubtless an individual trait. As evidenced by the sulcus, the vertebral shields were hexagonal with a small projection in the centre of the anterior margin. The posterior border of the fifth slopes downwards to the sulcus on the eleventh marginal, whence it apparently crosses the pygal on the same horizon. The vertebrals are nearly as broad as long, but compared with the costals narrow. The latter are much longer than broad. The posterior marginals are slightly fluted parallel to their edge.

The plastron is strongly united to the carapace by suture. On the seventh marginal there is a very powerful inguinal buttress, which from the prominence of its ridge at the marginal suture

extends on to the fifth costal. The entoplastral bone is rounded posteriorly and intersected by the humero-pectoral sulcus, which traverses the plastron in a sinuous line. The pectoral-abdominal sulcus touches the posterior hyoplastral suture at the right angle, formed with the median suture; from here it gradually curves upwards to the height of about a quarter the length of the hyoplastral, when it rapidly falls, passing from that plate at the point of union of the outer and lateral posterior suture; this sulcus becomes remarkably deep in the central region of the plastron, forming a very marked feature.



Shell of *Nicoria headonensis*, sp. nov.

1, shell (carapace); 2, plastron; 3, part of the inguinal buttress.
From Lower Headon Beds, Hordwell, Hants.

This specimen comes within the family Testudinidæ by the complete ossification of the shell, the union of the plastron with the carapace by suture, the ovoid character of the carapace, and its covering of epidermal shields. Further, from the neural plates being short-sided behind, and the entoplastron intersected by the humero-pectoral sulcus, it may be referred to the genus *Nicoria*, as arranged by Mr. Boulenger in his synopsis of the genera of this family in the British Museum Catalogue of Chelonians. The second neural bone and the general form of the vertebral and costal shields show a strong resemblance to the recent *Nicoria trijuga*; but it differs in not having its fifth neural bone octagonal, and its sixth short-sided in front. It also differs from *Nicoria tricarinata* (from the Pliocene of the Siwalik Hills) in the carapace not being so elongately oval, in exhibiting no carination, and in the form of the vertebral and costal shields. It is also distinguished from its variety

sivalensis by the same characters, and by the plastron being connected to the carapace by suture and not by ligament.

Apparently the fossil now described represents a new species; it would therefore be well to designate it *Nicoria headonensis*. This, we believe, is the first record of the genus from England. At the present day *Nicoria* is found in the East Indies and Central and South America.

NOTICES OF MEMOIRS, ETC.

On the Significance of Pneumatic Foramina in Fossil Bones.

In a paper "On a Pneumatic Type of Vertebra from the Lower Karroo Rocks of Cape Colony" (Ann. & Mag. Nat. Hist., ser. VII, vol. xiv, November, 1904, pp. 336–344), by Professor H. G. Seeley, F.R.S., the author makes (on p. 341) some interesting remarks on pneumatic foramina in fossil bones which appear sufficiently important to reproduce here:—

"Doubt has of late been current concerning the significance of pneumatic foramina in fossil bones, and is put forward verbally and in print by Professor H. F. Osborn. In an article in the *Century Magazine* for September, 1904, similar in scope to the lecture given at Cambridge in August to the British Association, he enunciates the same views. Writing of *Ornitholestes*, Professor Osborn remarks:—'Externally its bones are simple and solid-looking, but, as a matter of fact, they are mere shells, the walls being hardly thicker than paper, the entire interior of the bone having been removed by the action of the same marvellous law of adaptation which sculptured the vertebræ of its huge contemporaries. There is no evidence, however, that these hollow bones were filled with air from the lungs, as is the case of the bones of birds.'

"*Ornitholestes* is compared with *Cœlurus*, *Hallopus*, *Ornithomimus*, and *Aristosuchus*. It is known from the skull, forty-five vertebræ, pelvis, and representative parts of both fore and hind limbs of one individual (Bull. Am. Mus. Nat. Hist., vol. xix, p. 459). But from the context quoted I gather that the author's conclusions should be applied, not only to *Ornitholestes*, but to the pneumatic vertebræ of the largest Dinosaurs, possibly to all fossil pneumatic bones which are not referable to birds.

"The current belief that a pneumatic vertebral column is evidence of the prolongation into the bones of air-cells from the lungs is an inductive conclusion, based upon the evidence from the parallel condition in the bones of birds. This evidence is affirmed by Professor Osborn, in the passage quoted, not to exist, and in place of it he offers what is termed the 'Law of Adaptation' as having sculptured these huge vertebræ. I have met with no enunciation of this law; and until it is explained how it differs in physiological action from the processes which sculpture or excavate the bones of birds, it will be difficult to judge whether we are offered a law,

a suggestion, or only words, for no law will produce anatomical effects without corresponding physiological circumstances to sculpture the bones.

"If the influence of pneumatic pressure produces a well-known osteological result in excavation of a bone in a bird, what is there in the vertebræ of a Dinosaur to suggest that similar effects have been produced by dissimilar causes? And it would be interesting to find in an extinct order of animals evidence that an agency unconnected with the lungs produced results which differ from those in birds only in being the effect of larger areas of pressure acting laterally upon the sides of the vertebræ. But the evidence that there was any essential difference in the origin of these structures in Dinosaurs and birds is not forthcoming; and if it ever existed is lost with the soft parts of the animal.

"Nevertheless, cavities are formed in certain bones in animals of varied organization, which are not connected with the lungs in the manner of air-cells of birds, but they are chiefly in the skull. They are slightly developed in existing reptiles, but are most conspicuous in warm-blooded animals. The skulls of elephants exhibit a maximum development of pneumatic cavities which have no connexion with the lungs, and the texture of these bones closely approximates to that of cellular vertebræ in some Cetiosaurian Dinosaurs, such as *Ornithopsis* and its American representatives. The resemblance between the mammal skull and the reptile vertebra is one of analogy. There are no facts to support the inference that the cause which *expanded* the cranial bones of the elephant and other mammals is identical with that which absorbed and excavated the bony tissue, but did not augment the size of the cervical and dorsal vertebræ of Dinosaurs. There is no basis for comparison between the conditions in mammals and these extinct reptiles, for no mammal shows a pneumatic vertebral column which can be compared with these Dinosaurs; and when a mammalian vertebra is hollow it is not comparable, since there is no pneumatic foramen.

"On the other hand, Dinosaurs are not conspicuous for pneumatic cavities in bones of the skull, and there are therefore no facts to suggest the idea that they might by analogy develop a pneumatic vertebral column which was not connected with the lungs, even if the cranial and vertebral pneumatic structures had been comparable.

"The influence of the lungs as a whole in modifying the vertebral column of a reptile is manifest in the dorsal vertebræ of Testudinata. In tortoises, under conditions of terrestrial life, the lungs have expanded and given the carapace a remarkable elevation. At the same time the neural arches have become raised, and the lungs have pressed evenly against the sides of the centra of the vertebræ till they have become narrowed into thin plates by the tissue being absorbed laterally. But the lung never penetrates into the substance of the vertebra or excavates holes in the bones in existing reptiles comparable to those seen in skeletons of Dinosaurs, Ornithosaurs, and birds.

"The influence of the lungs on the vertebral column of a Dinosaur as distinct from the air-cells may be, perhaps, inferred from the elevated condition of the neural arch and upward direction of transverse processes under which the lungs extended in such a type as *Diplodocus*, described by Professor Osborn and the late Dr. J. B. Hatcher. It is reasonable to infer that the lungs were so large that their intermittent upward pressure stimulated the growth of the neuro-central suture to form the high neural arch; but as they were not confined by an unyielding envelope in the same way that the carapace confines the lungs of tortoises, there is but little lateral compression of the body of a vertebra as a consequence of absorption, which was localized laterally about the pneumatic foramen.

"All down the vertebral column in *Diplodocus* the vertebræ are excavated, and the lateral holes were termed by Dr. Hatcher pleuro-central cavities. They have been well described in *Ornithopsis*. Their distinctive feature is that in the dorsal region the lateral foramina expand within the centrum into large chambers separated by a median vertical longitudinal partition, and each is commonly divided into unequal anterior and posterior parts by an imperfect vertical transverse lamina of bone. From this primary lateral cavity bone-cells commonly extend to the articular faces of the centrum and other parts of the vertebra. This condition of the pneumatic vertebræ is only dissimilar to that of birds in its details. In no existing animals except birds is a similar pneumatic structure found in the vertebral column, and it is only known in connexion with air-cells prolonged from the lungs. There is no fact to suggest that the lungs themselves were extended into the pleuro-central cavities of Dinosaurs: such an idea is not consistent with the pneumatic condition of the vertebræ in the elongated neck and tail. But with the general resemblance to the condition in the bones of birds it has been inferred that the pneumatic pressure, which was persistent enough to absorb the bone locally and laterally, was greater in Dinosaurs than in birds, because the cavities excavated are larger. Although this pressure, judged by its effects, was most potent in the dorsal region of the lungs, it also extended to the neck and tail, as in certain birds. It is therefore inferred that no cause is known except prolongation of air-cells from the lungs into the bones which is capable of producing these results, for from no other source in nature is the pressure derived which penetrates in this way into the skeleton.

"This is inductive evidence from physiology and comparative anatomy. In place of it Professor Osborn has offered nothing except the following passage:—'The dominating principle in construction of the backbone is maximum strength with minimum weight. The ingenuity of sculpture by which this is brought about, every single vertebra differing from its fellow, baffles the Lamarckian as well as the Darwinian, and tempts us to revive the old teleological explanation.'[1] Teleology is not known as an element in science, and explains nothing."

[1] Memoirs American Museum of Natural History, vol. i, part 5, p. 193, "A Skeleton of *Diplodocus*."

REVIEWS.

I.—Geological Survey of Canada. Robert Bell, M.D., Sc.D., LL.D., F.R.S. Annual Report, Volume XIII: Reports A, D, DD, F and FF, K, L, M and MM, R, S. 1900. 8vo; pp. 747, xvii, 15 plates, figures, and 8 maps. (Ottawa: S. E. Dawson, 1903.)

THIS volume is in the usual form of a number of independent reports, each distinguished by a letter and separately paged, which have been issued previously as completed. It is presumed to refer to the operations of the Survey to the end of the year 1900, but some of the reports are based on observations not made till 1901.

The first Report (A), extending to 203 pages, contains a general summary of the Survey work for 1900. It was drawn up and submitted by the late Director of the Survey, Dr. G. M. Dawson, in January, 1901, and was probably his last piece of official work, for his death took place in the March following.

Beginning in the extreme north-west of the Dominion, mention is first made of the exploration by Mr. R. G. McConnell of the valley of the Stewart River and of a part of the Yukon, of which it is a tributary. The country bordering the rivers is mountainous; the rocks are of granite, granite-gneiss, quartz and hornblende schists, and crystalline limestones, overlain by dark siliceous slates. On the Klondike River there are outcrops of soft shales and sandstones with beds of lignite, which is mined for heating purposes. These beds are probably of Tertiary age.

In British Columbia, the further investigations of Mr. J. C. Gwillim, in the mountainous district between the Atlin and Teslin lakes, show that the rocks are mainly of quartzite, limestone, and greenstone, whilst at lower levels there is a great thickness of sandstone, apparently Cretaceous in age. In the Districts of East and West Kootenay, work was carried on by Mr. R. W. Brock and Mr. J. McEvoy, and a report of the Crow's Nest Coalfield, west of the summit of the Rocky Mountains, shows that in this district limestones containing *Productus* are succeeded by Cretaceous conglomerates, shales, and sandstones, with beds of coal, in an apparently continuous section 5,000 feet in thickness.

In the Mackenzie District, at the far north, Mr. J. M. Bell explored the regions between the Great Slave and the Great Bear Lakes, following the Mackenzie and Bear Rivers, and notes the presence of Archæan, Palæozoic, Cretaceous, and Tertiary rocks. Round the Great Bear Lake there are wonderful examples of old shore-lines indicating the former extent of the lake. In some places on the north-west side they are over 300 feet in height and 3–4 miles back from the present shore. Near the shore itself there are also broad beaches and terraces of pebbles from 10 to 100 feet in height.

In the Province of Ontario, Mr. McInnes reports on the areas round Port Arthur to the international boundary, and Dr. R. Bell (the present Director) gives the results of his survey of the

Michipoten District, including a description of the great mass of hematite ore at the Helen Mine.

In the Province of New Brunswick, Professor L. W. Bailey has determined the Ordovician and Silurian age of the rocks of the so-called great slate belt, and he has also contributed a separate report on the Carboniferous System of this Province with respect to the occurrence of workable coal-beds. The same subject is also treated by Mr. H. S. Poole, who arrives at the conclusion that to the north of the coastal range there are no equivalents of the productive Coal-measures of Nova Scotia, and that the prospects of any thick seams to the south of the range are similarly unfavourable.

In Nova Scotia, Mr. H. Fletcher has examined the south-western corner of the Springhill Coalfield and the Inverness Coalfield in Cape Breton.

Of the other reports in the volume, may be mentioned that by Mr. A. P. Low on the barren region bordering the east coast of Hudson Bay, from Cape Wolstenholme to the south end of James Bay. The northern and southern portions of the coast are of low, rounded hills of gneiss or granite, whilst the intermediate area consists of bold hills, 1,000 feet or more in height, of granite or trap. Argillites, greywackes, and cherts, associated with large masses of magnetite and hematite, and overlain by cherty carbonates of iron, magnesia, and lime, are likewise present. The series is capped by limestones, dolomites, carbonaceous shales, and sandstones. The sedimentary rocks are traversed by large vertical dykes of diabase, and subsequently by enormous irruptions of granite, which have considerably altered their characters. Fossil evidence of their age is wanting, but they are regarded by Mr. Low as pre-Cambrian. The geology of the basin of the Nottaway River, an extensive region lying to the south-east of James Bay, or between the Upper Ottawa and the Rupert River, was explored and partly surveyed by Dr. R. Bell in 1895–6, and in a brief report and on his map it is shown to consist largely of Laurentian gneiss with belts of crystalline schists, granites, and greenstones of Huronian age.

There is also a report by Mr. J. B. Tyrrel on the north-eastern portion of the Saskatchewan District and adjoining portions of the Keewatin. The greater part of these areas is underlain by Laurentian gneiss and granite and Huronian schists. Undisturbed limestones of Trenton and Niagara age overlie the older crystalline rocks, and these in turn are covered by Pleistocene (glacial) clays.

Further reports comprise an elaborate description by Mr. J. A. Dresser of the geology and petrography of Shefford Mountain, Quebec, illustrated by plans and figures. The mountain is considered to be of laccolitic origin. The report of the Section of Chemistry and Mineralogy by Dr. G. C. Hoffmann and his assistants, Messrs. Wait and Johnston, consists mainly of determinations of ores and rocks of but little general interest. The concluding report of the Section of Mines by Mr. E. D. Ingall and Mr. J. McLeish, extending to 160 pages, principally consists of statistics of the output and value of the metals, minerals, and structural materials obtained in the Dominion during 1900.

II.—The Recent Work of the Norwegian Geological Survey in the Hardanger District.

W. C. Brögger: "Lagfölgen paa Hardangervidda," Norges geologiske Undersögelse, 1893.
H. Reusch, J. Rekstad, and K. O. Björlykke: "Fra Hardangervidden," Norges geol. U., 1902.
H. Kaldhol: "Suldalsfjeldene," Norges geol. U., 1903.
J. Rekstad: "Fra höifjeldstrøget mellem Haukeli og Hemsedalsfjeldene," Norges geol. U., 1903.

THE Hardanger Vidde is a great desolate plateau with an average level of some 4,000 feet above the sea, situated east and south-east of the head of the Hardanger Fjord. It is dotted over with patches of snow, and one fairly extensive snowfield, the Hardanger Jökel, lies upon it. A glacier, the Rembesdals Brae, descends from the snowfield into a little mountain lake above the top of the waterfall Rembesdalsfos, but though the scene is one of great beauty it is seldom visited by the tourist, the path being very tedious and the climb up the rock near the waterfall somewhat difficult.

No part of the Hardanger Vidde, indeed, is well known to the foreigner, though there is a comfortable little hotel on its edge just above the great waterfall Vöringfos, and a few English find their way out on to the Vidde in search of sport.

Until recently the geology of the district was almost unknown, but now the Geological Survey of Norway have taken it in hand and several notices of their work have appeared in the Year Books. Still, these can only be looked upon as preliminary reports, for an extension of the survey further to the north is required to clear up some of the problems which have arisen. In the Year Book for 1903 there is, too, a short report on the geology of the mountainous tract which lies around the Röldal Lake, the Suldals Lake, and the Hyls Fjord, and this tract may fairly be treated as a southern continuation of the Hardanger Vidde District.

The geological formations found over the surface of the Hardanger Vidde and the Suldals Fjeld are as follows:—

Glacial and Recent.	Peat, Gravel and Sand, Moraines, Moraine Débris, Raised Terraces, etc.
Silurian.	(1) Mica Schist and Phyllite with subordinate beds of limestone. (2) Blue-grey Quartzite.
Cambrian.	Dark-coloured schists and slate.
Algonkian.	The Telemark Formation. Gneiss, Quartzite, Hornblende schist.
Archæan.	Gneiss.

Considerable masses of igneous rock are found associated with the above strata, and belong to at least three distinct periods—

A. Granite newer than the Silurian strata of the district.
B. Granite which was intruded between the date of the Algonkian and the Cambrian.
C. Igneous rock, mainly basic, now greatly altered and folded together with the Archæan Gneiss.

Up till recently the Norwegian geologists added another formation to the above list, placing it above what is now classed as Silurian strata, but it seems to be proved that the rocks assigned to that formation are in fact masses of the older granites, gneisses, etc., which have been thrust over the Cambrian and Silurian strata.

The result of the work of the Survey recorded in the published reports shows that the geological history of the district is somewhat as follows :—

Archæan.

The green and white gneiss so common in the adjoining districts is seldom found here in continuous masses below everything else. Mr. Rekstad records an occurrence some little distance eastward of the snowfield Hardanger Jökel and another on the north of the mountain Hallingskarvet. Patches of the old gneiss are, however, common, lying in or upon the granite B in the above list.

Mr. Björlykke mentions one such patch south of Skjaegge Dal on the east of the Sör Fjord. It lies upon the granite, and consists of greyish compact micaceous gneiss, sometimes with hornblende or chlorite, with layers of hornblende schist and also of a rock like saussurite gabbro. In places, too, there is gneissic granite, but the hornblende rock is the most common.

The Algonkian or Telemark Formation.

Rocks which are assigned to this formation are developed to a considerable extent along the Sör Fjord. They do not reach the head of the fjord at Odde, being cut off by the granite B a little north of that place. Fairly large areas of the Telemark Formation have also been found near Hallingskarvet in the north of the district and near the Hyls Fjord in the Suldals Fjeld. The formation consists of gneiss, sometimes fine-grained and passing into varieties resembling quartzite, of beds of quartzite, and of layers of hornblende schist. In places conglomerate occurs.

Associated with these rocks there are on the Sör Fjord massive rocks resembling saussurite gabbro in lens- or dome-shaped masses. The formation is penetrated by numerous granite veins which in places have been crushed into lens-shaped patches.

The Older Granite.

Both the Archæan Gneiss and the Telemark formation are, in the district of which we are speaking, to a great extent cut out by granite. This granite is older than the Cambrian and Silurian rocks of the district, for they are never penetrated by veins from it. The Telemark formation, on the contrary, is cut by granite veins in all directions.

The granite, according to Mr. Rekstad, often contains oligoclase as well as orthoclase, and this is more especially the case in the district north of the Hardanger Jökel. The mica is usually black, light mica only occurring to a small extent.

The granite is frequently porphyritic, and the rock is usually more or less gneissic, sometimes assuming the form of augen-gneiss. Pegmatite veins and also quartz veins run through it here and there,

and included patches of basic rock, of the old gneiss, and of the Telemark formation are common.

The granite platform upon which the Cambro-Silurian strata rest is one of the striking features in the geology of the Hardanger Vidde. It is suggested by Mr. Rekstad that this platform may possibly be a pre-Cambrian surface of erosion, and in that case, as he points out, it is remarkable that it should have retained its horizontality through the elevation of the Scandinavian highlands and through the vast period which has elapsed since. It is, however, possible that it may be a thrust-plane.

The surface of this platform is usually from 3,000 to 4,300 feet above the sea so far as the Hardanger Vidde is concerned, and consequently the magnificent sections which we see as we pass through the valley of the fjord and its branches are in the granite, the gneiss, or the Telemark formation, and it is not until we emerge from the valley on to the high ground of the Vidde itself that we come to the Cambro-Silurian.

The most accessible place on the Hardanger Vidde at which the junction between the granite and the overlying Cambro-Silurian can be seen is the mountain Grytefjeld, above the head of the Maabödal. If we mount up the zigzag path near the great waterfall Vöringfos we see that mountain before us when we emerge from the valley. Its appearance is very remarkable. The lower and main part is of a light colour, whilst on its top there is a dark cap. The light-coloured rock is the granite and the cap is the Cambro-Silurian. The boundary between them at this point appears to be a thrust plane, for Dr. Reusch found that the topmost part of the granite was foliated parallel with that boundary.

In some places the Cambro-Silurian strata rest upon old gneiss or upon Telemark formation, but the platform usually consists of granite. In the Suldals Fjeld Mr. Kaldhol found a conglomerate which he thought might be the basement-bed of the Cambro-Silurian, but at the same time he says it may belong to the Telemark formation, and over the rest of the district there does not appear to be any basement conglomerate to the schists.

In places there is at the bottom of the schists a bed of arkose-like sandstone, and in others a bed of felspathic quartzite, in each case containing flakes and layers of schist.

The Cambrian.

The Cambro-Silurian Series is divided into three divisions, the lowest of which is provisionally classed with the Cambrian and the two upper with the Silurian. The lowest division consists of dark-coloured schist not unlike the alum slate of the Christiania district. The rock gives a black streak. It is much crumpled and contains many quartz eyes. There is a good deal of finely disseminated pyrites, which gives a yellow-brown colour to the weathered surface. When not folded the thickness is from 90 to 150 feet. *Dictyonema flabelliforme*, Eich., and traces of some other fossils have been found in these black shales. In the Suldals Fjeld these black beds are sometimes wanting.

The Silurian.—The Blue-grey Quartzite.

On a great part of the Hardanger Vidde the black Cambrian schists are overlain by thickly bedded, blue-grey quartzite, in some places associated with a little calcareous sandstone. It is traversed by numerous veins of white quartz, often with cavities containing good rock crystals. The thickness of this quartzite varies from a few yards up to 180 feet. In some parts of the district it is absent, and in the Suldals Fjeld it appears to be represented by a greyish quartzite with schistose layers on the bedding-planes. A very similar blue quartzite is found in Valdres, Gausdal, and other districts of Norway, and Professor Brögger suggests that it possibly belongs to the lower part of Etage 3 of the Cambro-Silurian.

Above the blue-grey quartzite there is frequently a bed of grey or yellowish, rather fine-grained, crystalline limestone, containing flakes of mica and chlorite; these flakes become more and more numerous in the upper part of the limestone, until the limestone becomes a calcareous schist and finally passes into the overlying schists.

Professor Brögger suggests that this limestone may correspond to the Orthoceras Limestone which occurs at the top of Etage 3 in the Christiania district. This limestone in Hardanger Vidde attains a maximum thickness of about 30 feet. Apart from this limestone there is above the blue-grey quartzite a considerable thickness of schists of a very variable character, as a rule becoming coarser-grained in the upper beds. If the limestone above the blue-grey quartzite corresponds to the Orthoceras Limestone, then these schists will fall into Etage 4 of the Cambro-Silurian System.

The Great Thrusts.

The summits of the district are occasionally formed of the blue-grey quartzite, since owing to its hardness it has withstood denudation better than the schists, but the tops of the mountains and the high ground much more frequently consist of older and still harder rocks which have been thrust over the Cambro-Silurian.

We have mentioned that the Cambro-Silurian rests upon a remarkably even platform of granite and gneiss, but they themselves have been greatly crushed and folded, and it is probable that this crushing and folding were mainly caused at the time of the thrust movements, the soft schists and associated beds having been compressed between the old rock platform and the overthrust mass of hard granite and gneiss. In consequence it is found that, though the bottom of the schists is so level a plane, their top is often most irregular, being puckered and contorted with the overthrust mass. The most accessible place at which to study the relation of the overthrust mass to the other beds is the pass between Seljestad and Breifond, above the celebrated winding road known as Horrebrækkene. The succession is as follows:—

1. Overthrust mass of gneiss, granite, etc., forming the top of the mountain Horrehei.
2. Silurian schists, etc.
3. The black schists of the Cambrian.
4. Granite, gneiss, etc.

The overthrust mass contains not only the oldest granites and gneisses, but also masses of Telemark formation, and even some of the Cambro-Silurian schists, all folded up together.

These overthrust rocks were described by Kjerulf under the name Höiefjeldskvarts and by Brögger as the "Yngre Gneisformation," and the probability that their position is due to overthrusting was not definitely stated by those authors.

In the south-western part of the Hardanger Vidde there is a large area of the overthrust rock extending on the high ground from above Odde to above Röldal, and on a line parallel to the north-eastern boundary of this tract there is a row of high peaks, the lower part of each consisting of Cambro-Silurian and the summit of a mass of the overthrust rock. Mr. Rekstad found that these mountains capped with the blocks of overthrust rock rest each in a hollow in the Cambro-Silurian, for in every case he noticed on going round one of them the schists dip on all sides towards that particular peak.

The Younger Granite.

Hitherto it does not appear to have been known that any of the granite in this district was newer than the Cambrian, for though the Telemark formation is penetrated in all directions by granite veins none have hitherto been recorded as cutting the Cambro-Silurian.

Mr. Kaldhol has now, however, found that the granite of the Suldals Fjeld is of two ages, and on the south of the little lake by the Skardnut he noticed granite cutting the schists and altering them into hornfels. In other places there are bed-like patches of granite in the schists, in the neighbourhood of which there is a distinct false lamination, and small fragments of schist occur in the granite. This younger granite is of medium grain, with very little sign of foliation.

Faults.

The rocks of the district are intersected by numerous faults, and the influence of these faults on the surface features is discussed at some length. The valleys of the district may be divided into two classes: (1) the wide open valleys of the high ground; (2) the fjord-valleys, by which we mean the great valley of the Hardanger Fjord itself and its branches. The bottom of these fjord-valleys is now in part submerged beneath the water of the sea and in part above sea-level. In many cases the fjord-valley has been excavated along the bottom of one of the older wide open valleys of the high ground.

The river Bjoreia flows for many miles through one of the wide open valleys of the Hardanger Vidde, and at the great waterfall Vöringfos it plunges into a fjord-valley, the Maabödal.

In the Year Book for 1900 Dr. Reusch suggested that the position of the waterfall and the direction of the Maabödal were due to faults, cracks, or lines of weakness in the rock in which the valley has been cut; and in the Year Book for 1903 Mr. Rekstad deals with the

part of the valley above the waterfall, giving evidence to show that it is due to faults running along both sides of the valley, and is in short what has been termed a 'block valley.' Several cases are instanced where a valley follows the line of a fault. Thus Rossemyrnut is capped by the Telemark formation, and Mr. Kaldhol believes that it is a sunken part, a line of fault following the valley, for the granite on the opposite side of Grubbe Dal rises to about the level of the summit of Rossemyrnut. In the Year Book for 1902 Mr. Rekstad gives an example of a valley on the line of a fault near Juklevasrusten, in the centre of the Hardanger Vidde; and in the Year Book for 1903 he gives another instance in Gjuvedal, a small valley a little north of and nearly parallel to the Maabödal, down which the Bjoreia flows.

The ice-marking, perched blocks, moraines, etc., of the Glacial Period, as well as the raised terraces, receive attention in these memoirs, and the whole work is well illustrated by a series of photographs taken for the most part by Mr. Rekstad, and very satisfactorily reproduced both as plates and in the text. In conclusion, we can confidently recommend the Hardanger Vidde as a most interesting district, not easy to visit, but with plenty of sections, though not infrequently, judging from the accounts of the surveyors, a critical point is apt to be an inaccessible wall of rock or concealed by snow or talus débris. H. W. Monckton.

III.—A Handbook to the Geology of Cheltenham and Neighbourhood. By L. Richardson, F.G.S. 8vo; pp. xii and 268, with geological map, 19 plates, and 19 text-illustrations. (Cheltenham: Norman, Sawyer, & Co., 1904. Price 5*s.* net.)

THE Cotteswold Hills and the Vale of Gloucester have attracted a large amount of attention since Murchison and Lonsdale more than seventy years ago made known the general structure of the district, and stirred up interest in the rich fossil-beds of the Lias and the Oolites. During these years the steady increase of knowledge has been fostered by the Cotteswold Naturalists' Club, which numbered among its earlier workers such men as H. E. Strickland, James Buckman, John Lycett, P. B. Brodie, and Thomas Wright.

Murchison's "Outline of the Geology of the Neighbourhood of Cheltenham," published in 1834, was revised and augmented by J. Buckman & Strickland in 1845; Lycett's Handbook of "The Cotteswold Hills" and Hull's Geological Survey Memoir on "The Geology of the Country around Cheltenham" were issued in 1857; and Witchell's "Geology of Stroud" was published in 1882. A study of these works shows the increasing attention paid to the stratigraphy and palæontology of the Cotteswold Hills and bordering vales, while a kind of climax in minute subdivision of the local strata and of the fossil genera and species has been reached in the later works by Mr. S. S. Buckman. Inspired to a large extent by the teachings of that palæontologist, or we might preferably say field-palæontologist, Mr. Linsdall Richardson, who is Honorary

Secretary of the Cotteswold Naturalists' Field Club (as it is now termed), has given us the latest results of research in the fascinating region of Cheltenham. We may at once say that the work bears abundant evidence of his knowledge, diligence, and enthusiasm. He has brought together the available material that bears on the geology, and especially on the life-history of the local rocks from the Trias to the Forest Marble. We find consequently much information on the horizons of fossils, as well as on the zones, which, being based on palæontological evidence, are naturally independent of the ordinary limits of geological formations. The term *zone* is used to imply the deposits (of whatever character) of a particular period of time; while the term *hemera* is used to denote the time of a zone. As defined by Mr. Buckman the hemera is "the time during which a particular species—generally in Mesozoic chronology, of an ammonite—has dominant existence." With his aid the author enumerates 29 hemeræ for the Liassic series and 16 for the Inferior Oolite series. We should agree, however, with Mr. Hudleston in maintaining "the chronological value of Ammonite zones," and we prefer to consider the hemeræ as minor adjuncts of zones.[1]

It is evident that to follow the author much preliminary knowledge will be required. His work is an advanced rather than an introductory guide, and it appeals much more to the specialist than did any of the handbooks previously published. Thus, in describing the zone of *Schlotheimia angulata* (p. 40), he observes that "Beds usually referred to this zone have been found to have accumulated during two hemeræ—the hemeræ *megastomatos* and *marmoreæ*." We fail to find any explanation of these two hemeræ. There are many other hard nuts for the student to crack, if he be not specially instructed in the vicissitudes of palæontological nomenclature. No doubt the most difficult part of the author's work has been to employ the latest names assigned to the species he mentions. Thus *Ammonites raricostatus* (after three or four intermediate names) is now *Echioceras raricostatum*. The *Opalinum*-zone is duly noted, but we are by no means sure that any fossil corresponding to *Ammonites opalinus* is now recognized in the district, although included in the *Opalinum*-zone are the "*Opaliniforme*-beds" with *Cypholioceras opaliniforme*.

Here we may remark that we do not like the vague name "pre-planorbis beds," introduced by the author for the *Ostrea*-beds at the base of the Lower Lias. He finds fault with the term "White Lias," but it is a useful stratigraphical term for the Upper Rhætic beds in the region extending southwards from Bath.

The fact that zonal divisions often transgress the limits of ordinary stratigraphical divisions leads the author to speak of a "new school of geologists" who give "names to the time during which the beds were deposited," in contrast to an "old school of geologists" who placed "too much reliance upon lithic structure."

[1] See discussion in GEOL. MAG. for 1902, p. 554; 1903, pp. 36, 95, 141.

The present modes of dealing with geology are the outcome of a gradual growth from the foundations laid by William Smith in his "Strata identified by Organized Fossils"; the more detailed study of the succession of life-forms having been locally initiated by Strickland, and followed in ever-increasing detail. While the two schools may be said to be in active existence, there is no reason whatever for any antagonism between them. The "older" may be said to follow the broad outlines of Smith's grouping into stratigraphical divisions or formations, such as can be represented on geological maps; formations which indicate certain physical conditions, however local they may be, and the beginnings and endings of which must have varied considerably in point of time. None the less interesting are these formations and their fossils, their stratigraphical changes and method of origin; the part they play in the structure of the land, the relations of the rocks to the scenery and soils, and the economic applications of the strata. This aspect of geology is not one that collectively appeals very strongly to the author, the above matters being treated in a subordinate way when dealt with, and naturally enough. To work at the minute palæontological and chronological divisions demands not only special knowledge but prolonged and concentrated labour, otherwise the results can be of little value. The rocks, then considered rather as tombs for fossils, are not looked upon with the same affection as they are by those who are concerned mainly in tracing out the physical structure of a district.

The "new school," as it is called, is doing work on admirable lines. As Dr. Smith Woodward has remarked, "The variations of an organism in time and space, and its successive migrations, can only be ascertained by more detailed field-work and more precise labelling than has hitherto been customary among palæontologists"; indeed, "a most exact and exhaustive method of collecting" is necessary.[1] The work before us should therefore do much to stimulate further research on these lines in the Jurassic areas.

In considering this important task it is evident that to meet the requirements of both field-geologist and field-palæontologist two systems of geological nomenclature are requisite—the one dealing with formations, the other with epochs. In the new Guide to the Fossil Mammals and Birds (British Museum), lately noticed in the GEOLOGICAL MAGAZINE, this is fully recognized, the author (Dr. Smith Woodward) observing, "It is just because rock-formations in different parts of the world so rarely are equivalent that a time-scale is needed to which each can be referred."

We should not omit to mention that the present author deals briefly with the scattered superficial deposits of the Cheltenham district, but these have not yet been mapped out in detail, and, as he truly remarks, their history "remains to be written." A fuller knowledge of the valley drifts will no doubt throw light on the popular subject of river-development. Meanwhile the subject has

[1] Proc. Geol. Assoc., vol. xviii, p. 429.

been ably handled by Mr. S. S. Buckman, and a summary of his views is given in one of the chapters, illustrated by a good physical map and by an effective view of meanders of the River Coln.

The volume is illustrated also by six photographic plates of fossils, mostly from the writer's collection, and among these only two ammonites are pictured: *Paltopleuroceras pseudocostatum* belonging to the "spinati hemera," and *Liparoceras capricornu* to the "capricornus hemera."

We may repeat, in conclusion, that to the seriously minded worker on the Cotteswold Hills this handbook will be a real help in indicating the present knowledge of the zonal palæontology of the district. Details of a great many pit-sections are given, accompanied by some capital photographic illustrations and sundry diagrams; there are illustrations also of the *Girvanella* and its connection with the little concretionary nodules of the Pea-Grit. The Appendices comprise a short list of minerals, copious lists of fossils, and an explanation of the geological map, reproduced from that of the Geological Survey, to which the author has made some additions.

H. B. W.

IV. — Ore Deposits: a Discussion. pp. 90. (New York: Engineering and Mining Journal, 1903. Price 5*s.* net.)

EARLY in 1903 two meetings of the Geological Society of Washington were devoted to a discussion on the genetic classification of ore deposits, in which several well-known geologists (S. F. Emmons, W. H. Weed, J. E. Spurr, W. Lindgren, J. F. Kemp, F. L. Ransome, T. A. Rickard, and C. R. Van Hise), who have done special work on ore deposits in connection with the United States Geological Survey, took part. The discussion was fully reported in the pages of the Engineering and Mining Journal, and, together with an introductory review, it is now reprinted in book form. An article by C. W. Purington entitled "Observations on Gold Deposits" is also reprinted as an appendix from the same journal.

A tentative classification, on which the discussion was based, was proposed by W. H. Weed, an outline of which is given below. Other classifications are proposed by Spurr and Van Hise. Although there are still considerable diversities of opinion, it is interesting to note that the theory of 'lateral secretion' finds little or no favour. For nearly all deposits of any importance an igneous origin, either directly or indirectly, is ascribed.

Genetic Classification of Ore Deposits.

I. Igneous (magmatic segregations).
   A. Siliceous (aplite and quartz-veins).
   B. Basic.

II. Igneous emanations. Deposits formed by gases above or near their critical point.
   A. Contact-metamorphic deposits.
   B. Veins (closely allied to magmatic veins and to division IV).

III. Fumarolic deposits. Metallic oxides, etc., in clefts in lavas.

IV. Gas-aqueous (pneumato-hydato-genetic) deposits. Igneous emanations or primitive water mingled with ground-waters.
  A. Filling deposits.
  B. Replacement deposits.

V. Meteoric waters (surface-derived).
  A. Underground.
  B. Surficial.

VI. Metamorphic deposits. Ores concentrated from older rocks by dynamo- and regional-metamorphism.

V.—Manual of the Chemical Analysis of Rocks. By Henry S. Washington. pp. ix, 183. (New York, John Wiley & Sons; London, Chapman & Hall, 1904. Price 8*s.* 6*d.* net.)

THE object and scope of this work are well expressed by the first paragraph of the preface, which may, therefore, be quoted in full:—"The object of this book is to present to chemists, petrologists, mining engineers and others who have not made a particular study of quantitative analysis, a selection of methods for the chemical analysis of silicate rocks, and especially those of igneous origin. While the publication of such a work may seem superfluous in view of the existence of Hillebrand's treatise on this special topic, yet justification may be found in the fact that the latter is intended, not so much for one who is not very conversant with the subject, as for the practised analyst, to whom it is an indispensable guide."

With the exception of a few of the rarer chemical elements, the ground covered is the same as in Hillebrand's "Some Principles and Methods of Rock Analysis" (Bull. U. S. Geol. Surv., No. 176, 1900), which is the standard work on the subject. Fewer methods are, however, given, but these are described in greater detail so far as details of manipulation are concerned. A few figures of apparatus, such as are given by Hillebrand, would have added to the value of the book.

While, of course, it is of extreme importance to have analyses of rocks, yet it is still more important that these analyses should be accurate; and it is to be hoped that the apparent simplicity of the methods, as clearly stated in the book in such minute detail, will not lead to the multiplication of unreliable analyses by unskilled analysts.

VI.—Die Kristallinen Schiefer. I. Allgemeiner Teil. By Dr. U. Grubenmann. pp. 105, with 7 text-figures and 2 plates. (Berlin: Borntraeger, 1904. Price 3 M. 40 Pfg.)

THE author of this book, who is Professor of Mineralogy and Petrology in the University of Zurich, has for many years made a special study of the crystalline schists of the Alps, in which

study he has been closely associated with Professors F. Becke and F. Berwerth, of Vienna. The present volume gives a general discussion of the subject, based on physico-chemical principles. A second volume is reserved for the description of the crystalline schists of special areas.

Commencing with a brief historical review and concluding with references to the literature, the subject-matter is divided under four main headings, as follows :—

A. The original material and its specific characters.
B. Metamorphism.
C. The products of metamorphism in their various forms.
D. The geological occurrence of crystalline schists.

VII.—The Orbicular Gabbro at Dehesa, San Diego Co., California. By Andrew C. Lawson (Bull. Dept. Geol. Univ. California, vol. iii, 1904, pp. 383–396.)

A DESCRIPTION is given of the petrographical characters and field relations of an interesting type of gabbro from California. The normal type is a coarse-grained hornblende-gabbro with olivine and hypersthene, of which there are various local facies, one being the orbicular type. The spheroids, which were mistaken by the original finder of the rock for fossil corals, measure about six centimetres across. They consist of a core of felspar surrounded by concentric shells of radially crystallised olivine and basic felspar, the composition of the whole being that of a troctolite. Some suggestions are offered to explain the orbicular structure of igneous rocks, which though of somewhat rare occurrence is more common in acid than in basic rocks.

VIII.—Year-Book of the Scientific and Learned Societies of Great Britain and Ireland, etc. 21st Annual Issue. 8vo. (London : C. Griffin & Co., 1904.)

IT is obvious that a book of reference of this nature, after appearing for twenty-one consecutive years, has filled a want. The Year-Book is thoroughly appreciated by some secretaries, as shown by the up-to-date information supplied. There are still others, however, who lag behind. Why, for instance, has the Secretary of the Geological Society of Glasgow not vouchsafed any details for two years? We also note that Mr. Monckton is still put down as President of the Geologists' Association of London, though succeeded by Dr. A. S. Woodward last February.

Messrs. Griffin & Co. would add a piece of useful information to each of the smaller local societies if they could obtain from the secretaries the last date on which a publication appeared. "Nothing since 1900" would be greatly appreciated by librarians, from whom such information is frequently sought.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 21st, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On certain Genera and Species of Lytoceratidæ." By S. S. Buckman, F.G.S.

This paper deals with certain specimens sent by Mr. Beeby Thompson from the Northampton Sands, one of which is remarkable for its homœomorphy with *Phylloceras*. In order to classify the series of Toarcian–Aalenian Lytoceratidæ to which these species belong (*jurense* and allied groups), it is necessary to note that there is evidence of a definite sequence of phylogenetic stages. In ornament there is, at first, elaboration; but, later, simplification from a costate to a smooth stage. In whorl-shape there is a tendency to pass from the primitive evolute to the involute whorl, the umbilicus constantly contracting. Parallel with this there is a further tendency to pass from stout to more compressed whorls. While the Lytoceratidæ have a more primitive whorl-shape than the Phylloceratidæ, their lobe-line is more advanced; and hence, while the advance of the former produces a certain external homœomorphy with the latter, the more advanced lobe-line remains a feature of distinction. The successive stages of development may be indicated in terms of species, thus: (1) *Germaini*, (2) *torulosum*, (3) annulose species not yet named, (4) *jurense*, and (5) phylloceratoidan. Four new genera are described and two new species; three new names are proposed, and one generic name revised.

2. "The Leicester Earthquakes of August 4th, 1893, and June 21st, 1904." By Charles Davison, Sc.D., F.G.S.

The earthquake of 1893 was a twin, with its principal epicentre between Markfield and Woodhouse Eaves, and the other near Tugby, about 17 miles to E. 34° S. Its disturbed area contains about 2,200 square miles. In the north-western focus, the originating fault hades to the north-east, and is probably one of the group of faults on the north-east side of the Charnwood anticlinal axis, which appear to hade in the direction given. In the south-eastern focus, the fault hades in the opposite direction, the change of hade taking place a short distance to the south-east of Leicester.

On June 21st, 1904, two shocks were felt: the first a very slight one, at about 3.30 a.m.; the second at 5.28 a.m. The epicentre of the earlier shock was in the neighbourhood of Markfield and Groby, or near the south-eastern margin of the north-western focus of 1893. The second shock disturbed an area of about 1,200 square miles, and was a double shock, not a twin, for the foci were overlapping. It originated in a fault running nearly north-west and south-east, hading to the south-west, and passing a short distance from Tugby, and therefore in all probability coincident with

the fault in action in 1893. The distance between the epicentres of the earthquakes of 1904 was about 12 miles. Thus, the foci of 1904 appear to have occupied the nearer margins of the foci of 1893.

3. "The Derby Earthquakes of July 3rd, 1904." By Charles Davison, Sc.D., F.G.S.

Although weaker than the earthquake of March 24th, 1903, this shock, owing to its occurrence at 3.21 on a Sunday afternoon, was felt over a much wider area (about 25,000 square miles). As in 1903, the earthquake was a twin, the epicentres being almost exactly coincident with those of that year, one being situated near Ashbourne, and the other, about 6 or 7 miles from it, near Wirksworth and Matlock Bath. The impulse at the south-western or Ashbourne focus was slightly stronger than the other, and took place a second or two later. The principal slip was preceded by a slighter one in the north-eastern focus at 2.28 p.m., and was followed, as in 1903, though after a short interval, by a slip in the interfocal region of the fault, at 11.8 p.m.

4. "Twin Earthquakes." By Charles Davison, Sc.D., F.G.S.

In a twin earthquake, the shock consists of two maxima of intensity, or of two distinct parts separated by a brief interval of rest and quiet. In Great Britain one in every twenty earthquakes is a twin, and our strongest shocks (the Colchester earthquake of 1884, the Hereford earthquake of 1896, etc.) belong to the same class.

The two parts of a twin earthquake differ in their order of intensity, both in different earthquakes and in different parts of the disturbed area of the same earthquake. The interval between the two parts varies on an average from 2 to $3\frac{1}{2}$ seconds; and, although the twin shock is felt over a very wide area (sometimes over nearly the whole of the disturbed area), there may exist within it a band (the synkinetic band) in which the two parts coalesce and form a single shock.

These phenomena show that twin earthquakes cannot be caused by reflection or refraction of the earth-waves, nor by the separation of the waves of direct and transverse vibrations, nor by the repetition of the impulse within the same or an overlapping focus. They must therefore be due to impulses in two detached, or practically detached, foci; and it is shown that all the known phenomena of twin earthquakes can be thus accounted for.

In British twin earthquakes the distance between the epicentres varies from 4 to 23 miles, the average for seven recent earthquakes being between 10 and 11 miles. As a rule, the foci are elongated approximately in the direction of the line joining them, showing that they are portions of the same fault. The foci appear to be situated at different depths, and in two cases the fault probably changes hade in the region between them.

The existence of the synkinetic band and the brevity of the interval between the two parts of the shock show that, when the impulses are not absolutely simultaneous, the second takes place as a rule before the vibrations from the first focus have time to reach

the other. Thus, twin earthquakes are due to a single generative effort; and they are caused, it is urged, by the growth of a crust-fold cut transversely by a fault. If the movement is such that the anticline of the fold is made more anticlinal and the syncline more synclinal, the middle limb will remain practically undisturbed; so that, by a single effort, there will be two impulses in detached foci situated at different depths. The average distance between successive anticlines and synclines in France along several lines lies between 9 and 12 miles, which agrees closely with the average distance between the epicentres of twin earthquakes.

II.—January 4th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Marine Beds in the Coal-measures of North Staffordshire." By John T. Stobbs, Esq., F.G.S. With Notes on their Palæontology by Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

Owing to the disposition of the rocks and other causes, the stratigraphical position of the marine beds can be located with exactness *in situ*, and a large quantity of material can be obtained for examination. The horizons can be utilized for the identification of coal-seams and for the subdivision of the Coal-measures, as they are remarkably persistent, and can be frequently traced not only over the North Staffordshire field but in adjacent coalfields. The known horizons at which marine fossils have been obtained are the following, given in descending order:—

11. The roof of the Bay or Lady Coal.
10. The Priorsfield Ironstone Measures.
9. The Speedwell and Nettlebank Bed. } Below the Twist or
8. The Florence Colliery Band. } Gin Mine Coal.
7. Above the Moss Coal.
6. The roof of the Moss Cannel or Single 2-foot Coal.
5. Above the 7-foot Banbury Coal.
4. Beneath the 4-foot Coal of Cheadle.
3. The Knypersley Band.
2. Near the Crabtree Coal (three horizons).

And also 1. The Weston-Sprink Bed.

A map of the distribution of these beds is given, each one is described in detail, and a list of fossils found from the various exposures is tabulated. The Speedwell and Nettlebank Bed appears to be the most important marine bed in the coalfield; it is remarkably rich in species and individuals, and occurs in the upper portion of the true Coal-measures. Further, it proves the identity of the Twist coal of the Norton area with the Gin Mine of Longton. Lithologically, the marine beds are undistinguishable from the beds with which they are interstratified; but the fossils are usually in a good state of preservation and not confined to one particular bedding-plane; the individuals are likewise numerous. The marine mollusca are, however, sharply separated from the fresh-water forms, and no intermingling occurs. It is remarkable that several of the marine shales immediately succeed the coal-seams. A detailed table of the beds in North Staffordshire is

given, to show the exact position of the marine beds; and then several of the seams are traced into the Yorkshire, Lancashire, South Staffordshire, and Coalbrookdale fields. This tracing confirms the conclusion that the Hard Bed of Yorkshire is to be correlated with the Bullion coal of Lancashire and the Crabtree coal of North Staffordshire. Again, "Green's marine bed" at Ashton-under-Lyne coincides with the Gin Mine horizon of North Staffordshire; and this, again, with the Pennystone of South Staffordshire and Shropshire. Further, the marine beds indicate the approximate identity of the Silkstone, Arley Mine, and Cockshead seams. A bibliography is appended.

Dr. Hind, in his Notes on the Palæontology, remarks that from the base of the Pendleside Series to the top of the Coal-measures there is an unbroken succession of beds—at one time marine, at another estuarine, without unconformity. The two faunas—one with *Carbonicola*, *Anthracomya*, and *Naiadites*, the other with *Pterinopecten papyraceus* and Cephalopoda — occur in irregular alternations, the two faunas never mingling. The author proceeds to give notes on the occurrence of many of the species, and descriptions of some of them, including examples not hitherto known from Britain and one new to science. A table indicating the distribution of the species throughout the chief English coalfields concludes the paper.

2. "The Geology of Cyprus." By Charles Vincent Bellamy, M. Inst. C. E., F.G.S. With Contributions by Alfred John Jukes-Browne, B.A., F.G.S.

The following are the chief formations described:—

Pleistocene.	Sandy limestones. Sands and conglomerates.	Up to 50 feet.
Pliocene.	Shelly limestones, with calcareous sands and sandstones.	100 to 150 feet.
Break.	Intrusion of igneous rocks.	
Idalian (Oligocene).	White chalky limestones and marly chalks, with layers and nodules of flint.	About 1,000 feet.
	Grey and yellowish marls, with beds of gypsum.	400 feet.
Kythræan (Upper Eocene).	Grey felspathic sandstones and sandy shales.	? 1,500 feet.
Break.		
Trypanian (? Cretaceous).	Grey limestones and dolomites; white and pink marbles, both massive and laminated.	Possibly 6,000 feet.

The Kyrenia Mountains form the northern rampart of the Central Plains, and they rise abruptly to heights of over 3,000 feet from the plain to the south and the sea to the north. They are composed of rocks tilted into a vertical position, much altered by compression and intrusion, and are devoid of fossils. They are referred by Professor Gaudry to the Cretaceous Period, and are compared by him with the Hippurite Limestones of Attica. They are pierced and marmorized by igneous rocks of quartz-felsite type. In some places they are schistose. Similar rocks are found in the extreme south-west of the island.

The Kythræan rocks attain a great development along the southern side of the Kyrenian Mountains. They are based on breccias and conglomerates made up of fragments of the Trypanian Limestones, and are thus probably unconformable. No fossils, except a few small tests of *Globigerina* and a few fragments possibly of shells, have been found in this series, which consists entirely of volcanic débris embedded in a calcitic matrix, like the 'Macignos' of Italy.

The Idalian Series appears to rest conformably on the last. The gypsum beds are largely developed in the south; the white chalky marls and limestones extend over nearly one-half of the island, and are always conspicuous from their intense whiteness. Foraminifera are abundant, and other fossils have been found which indicate that the beds are mainly of Oligocene age.

Igneous rocks are most conspicuous in the centre of the island, forming a mass of mountainous ground. They are intrusive into the formations already mentioned. The rocks include augite-syenite, rhyolite, liparite, olivine-dolerite, basalt, augitite, and several varieties of serpentine. Considerable metamorphism and much jasperization occur in association with them.

While most of the older sediments were formed in deep water, the fauna of the Neogene rocks is that of shallow-water deposits. Miocene rocks have only been recognized in the south-east of the island. The Pliocene strata lie in horizontal or slightly inclined beds, resting unconformably upon all older rocks. The Pleistocene rocks comprise: (1) Littoral limestones and pebble-beds, (2) soft shelly sands, (3) inland surface-conglomerates, (4) cave-earths, and (5) alluvial deposits. The cave-earths have yielded *Hippopotamus minutus* and *Elephas Cypriotes* to Miss D. M. Bate. An account of the chief economic mineral products of the island is given, including the marbles, clays, limestones, gypsum, building- and paving-stones, road-metals, metalliferous minerals, pozzuolana, terre-verte; and a note on the springs, salt lakes, and soils. Descriptions of some of the rocks, a note on the Miocene rocks, and a sketch of the physical history of the island are contributed by Mr. Jukes-Browne.

III.—January 18th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communication was read:—

"On the Geology of Arenig Fawr and Moel Llyfnant." By William George Fearnsides, M.A., F.G.S.

This paper contains a detailed description of the succession of beds in Sedgwick's typical area of development of his Arenig Series. The following beds are described:—

Orthis limestone.
Thin ashy shales.
Upper ashes of Arenig and Llyfnant.
Dalfawr shales, with graptolites apparently of the *Didymograptus Murchisoni* zone.
Upper platy ashes, passing down into:—
Agglomerate.
Lower platy ashes.

Didymograptus bifidus beds: blue shales with ocasional ashes, passes down into:—
D. hirundo beds: dark calcareous shales, with some ashes.
Calymene ashes, with some calcareous material and occasional shaly beds.
D. balticus flags, quartzose flags with shaly partings.
Basal grit.

Unconformity.

Shumardia shales, passing down into:—
Asaphellus flags.
Bellerophon beds: hard shales, with *Parabolinella Salteri* in upper part.
Dictyonema band, *Niobe* beds, } not well exposed.
Peltura beds, with *Niobe* and *Psilocephalus* near the top, and *Peltura* abundant in the middle part. These are separated by thin beds with *Orthis lenticularis* from:—
Parabolina beds, with *P. spinulosa*.

The unconformity marks the base of the Arenig Series. The *Orthis* limestone yields Lower Caradoc Sandstone forms, and dips beneath the great Black Shale Series, which occupies the adjoining belt of country.

The author discusses the relationship of these divisions to corresponding beds of other areas. He gives a description of the intrusive igneous rocks, and some account of the structure of the district and the nature of its glaciation.

CORRESPONDENCE.

CAVITIES IN CRYSTALLINE ROCKS.

Sir,—The cavities in the granite of Madagascar, described by the Rev. R. Baron in your January number, appear to be even more remarkable than those in Corsica and Portugal. But his explanation, though very ingenious, is, I think, attended by difficulties of its own. Between the ordinary drusy cavities and these large smooth hollows the gap seems wide and incompletely bridged by any of comparatively small size. Also, might we not expect that such hollows would sometimes be cut into by quarrying, and then have attracted notice? I cannot remember to have read of their occurrence, and have never met with anything of the kind, though I have been in several quarries, including the one mentioned at Ajaccio itself. Again, several of these hollows at that place occur rather as depressions on the surface of a block than as holes in it, and in positions unfavourable to the idea that any fairly thick slice has been removed from the rock in comparatively recent times. Of such the cavity represented on p. 390 of the Geol. Mag., August, 1904, may serve as an example, and I remember others in similar positions on the slope behind Ajaccio. Moreover, as the granite is generally in good preservation, showing, as Mr. Baron also remarks, only a little surface-decomposition, it must be weathering away slowly, and it is rather surprising to find the cavities retaining their superficial glaze. His description, however, seems to exclude the explanation of sand blast, and makes that of water corrosion still more difficult. But a serious objection to his own hypothesis has, I think, been overlooked. At least one of the cavities described

by my friend Mr. Tuckett was not in granite but (as described by myself on p. 12 of last year's volume) in a rock which was more nearly allied to the pyroxenites and bore every appearance of having had the structure completely altered by pressure, which should have destroyed any pre-existent cavities. Thus, though deeming myself fortunate in having elicited such an interesting contribution to the discussion, I do not yet see my way to adopting his explanation of the difficulty. T. G. Bonney.

THE EASTERN GNEISSES OF THE SCOTTISH HIGHLANDS.

Sir,—Mr. G. Barrow's paper on the Moine Gneisses of the Highlands (Quart. Journ. Geol. Soc., November, 1904) revives memories of old controversies. In 1883 I gave reasons (Q.J.G.S., pp. 355–414) for believing that the thin-bedded gneisses east of the line of the great overthrust were older than the Assynt Series (now proved to be Cambrian), and I proposed to call them 'Caledonian.' Professor Lapworth's brilliant work on the dynamo-metamorphism of the Highland region quickly followed, and it suggested the possibility that the Eastern Gneiss was a *mélange* of rocks of different kinds and ages which had been rolled out in the earth-mill. However, the researches of the Geological Survey seem to have rehabilitated my original contention, since they lead to the conclusion that these gneisses, in the words of Dr. Horne, "represent sediments of siliceous and argillaceous type." Sir A. Geikie in 1891 proposed the name 'Dalradian' for the gneisses and associated rocks of the southern Highlands; but these are now correlated by the Survey with the Moine Gneisses of the north-west, that is, with my *Caledonian*. I held that these rocks were pre-Cambrian, but newer than the Hebridean; and this, I understand, is the view which Dr. Horne is disposed to adopt, when, in the debate on Mr. Barrow's paper, he points out resemblances between them and the pre-Torridonian schist north of Loch Maree. If therefore any name is to be given to these eastern gneisses, I respectfully submit that 'Caledonian' has priority over 'Dalradian.'

Mr. Barrow's memoir suggests another point. In my papers on the "Crystalline Rocks of Malvern" (1887–1893), I contend that black mica is produced from chlorite. This view was received with opposition. The peaceful pages of the Geological Magazine resounded with the weighty artillery of the late Lieut.-General McMahon thundering against "The Rape of the Chlorites." I declined to surrender, and now I am supported by Mr. Barrow, who remarks (p. 414) that "A striking feature of the grey gneisses is seen in the films of felted biotite, derived from original clastic chlorite . . . ." If chlorite is changed to biotite in Scotland, why not at Malvern, where too the associated acidic and basic rocks readily account for the necessary potash and iron-oxide? Since my heresy receives such respectable support it would seem to be worthy of reconsideration. C. Callaway.

Cheltenham.
December 27th, 1904.

THE DATE OF THE WORDS "ALTERED DEVONIAN" ON THE OLD GEOLOGICAL MAP OF SOUTH DEVON.

SIR,—Your reviewer has raised the interesting question as to the date when the words "Altered Devonian" were placed on the old Ordnance Survey Map of Devonshire of 1809.

As the Devonian system was only constituted in 1839 it must have been at or after that time. As De la Beche's Report was published in the same year all his work for the Report was completed before the term Devonian had come into use.

I venture to suggest the possibility that the term "Altered Devonian," whenever inserted, was not intended to apply to the metamorphic schist series but to the rocks immediately north of them, which, on the shores of Start Bay, are, I believe, universally admitted to be more or less altered. It seems impossible that De la Beche would ever have applied the term to the metamorphic schists further south, as he spared no opportunity to indicate his conviction that the latter were entirely distinct. De la Beche in his Report describes the different formations in successive chapters according to age. The schists are described in the chapter preceding that allotted to the grauwacke; and, in the epitome of contents, the superior antiquity of the schists is indicated without the shadow of doubt.

A. R. HUNT.

January 14th, 1905.

GEOLOGY OF THE KINGSBRIDGE AND SALCOMBE DISTRICT.

SIR,—In a somewhat lengthy notice of the Geological Survey Memoir on the "Geology of the Country round Kingsbridge and Salcombe," which appeared in your last issue (January, 1905, pp. 26–37), on p. 32 we read: "The general strike of the green schist zone, where the two bands coalesce to form one, would seem to be approximately north-west and south-east. This direction is oblique to the general strike of the Devonians on the north, and, taken in conjunction with the fact that the eastern half of the Metamorphic boundary consists of green schists and the western half of mica-schists, seems to point to a considerable difference of orientation in the two systems. Yet the author fails to trace any evidence of pre-Devonian disturbance."

The general strike of the green schist zone here referred to merely applies to about a mile of country between the Moult and Marlborough (see pp. 38–39 of the Memoir), where the flattening out of the great mica-schist anticline of the Start in a series of minor folds allows the southern band of green schist to coalesce with the northern band which all along its range is conformable in strike to the general strike of the Devonian rocks. The green schists are thrown out along a series of small east and west folds on the west of the Salcombe estuary, and it is owing to this circumstance, and not to any difference of orientation, that mica-schists are in contact

with Devonian on the west of the estuary. The maps bear out the above statements, and will show that the term band was not intended to mean a continuous outcrop.

Mr. Teall's description of the original character of the Metamorphic rocks and their likeness to Devonian sediments and igneous rocks associated therewith is a fact which deserves more consideration than the writer of the review seems inclined to give to it. As regards my own opinion as to the true boundary of Hope, that would depend on the acceptance of one view or the other, and to the age of the Metamorphic or metamorphosed rocks. Cogent facts are wanted, not opinions, and I am not prepared to enter any horse to win with. Certainly if I were I should not consider a plication of such magnitude as to repeat the Middle Devonian at Hope, a feat of legerdemain on the one side, or the repetition of similar conditions of deposit and of vulcanicity in the same area at widely different geological times, an impossibility on the other.

To be a strong partisan saves a good deal of troublesome investigation. Although no one can fail to see that the acceptance of an ancient series in the extreme south of Devon would be a convenient way of accounting for any extra disturbance in the Devonian rocks, the evidences of such, if present, are insufficient to afford material support to the pre-Devonian hypothesis.

W. A. E. Ussher.

'DEUTOZOIC.'

Sir,—When I used the word 'Deutozoic' I took it for granted that most of the readers of the Geological Magazine knew that the illustrious geologist who introduced the longer (and, etymologically, more correct) term 'Deuterozoic' had publicly sanctioned the employment of the word in its shortened form. J. G. Goodchild.

Royal Scottish Museum.
January 8th, 1905.

ON THE TERM 'DEUTEROZOIC.'

Sir,—The earliest work in which, to my knowledge, the word *Deuterozoic* is employed is Page & Lapworth's "Introductory Text-book of Geology," 12th edition, 1888, pp. 132, 133 (see also pp. 127, 129, 179, and 187 of same work). It includes the upper division of the Palæozoic, i.e. Old Red Sandstone, or Devonian, Carboniferous, and Permian. The lower division of the Palæozoic is termed *Proterozoic*, and comprises the Cambrian, Ordovician, and Silurian formations.

These terms *Proterozoic* and *Deuterozoic* do not seem to have taken hold, and have been neglected and forgotten except perhaps by Lapworth. I do not find any mention of them in any earlier geological work. In Lapworth's "Intermediate Text-book of Geology," 1899, he writes (p. 157):—

"By others [i.e. other geologists] the Palæozoic itself is divided

in the same way as the Neozoic into two periods: (*a*) the *Protozoic* or *Proterozoic* (Gr. *protos*, first), including the Cambrian, Ordovician, and Silurian; and (*b*) the *Deutozoic* or *Deuterozoic* (Gr. *deuteros*, second), embracing the Devonian, Carboniferous, and Permian."

Curiously, however, in the late Professor Gümbel's "Grundzüge der Geologie," which came out in parts (and the full volume in 1888), on pp. 527–529 the transition series is placed in the following three subdivisions:—

I. Cambrische or Proterozen System (*Paradoxides* period).
II. Silur or Deuterozen System (Graptoliten period).
III. Devon or Tritozen System.

I think Gümbel's employment of these terms must have been published before the 12th edition of Page's Text-book, though Lapworth may not have seen them, and he has given an altogether different signification to his Proterozoic and Deuterozoic to what Gümbel has done. F.G.S.

OBITUARY.

HENRY PALIN GURNEY, M.A., Hon. D.C.L., F.G.S., etc.

Born September 7, 1847. Died August 14, 1904.

Henry Palin Gurney, eldest son of Henry Gurney and Eleanor Palin, was born in London on September 7th, 1847. He received his early education at the City of London School, proceeding afterwards to Clare College, Cambridge. There he distinguished himself both in Athletics and the Schools: he rowed in the college boat and ran for his university in the Oxford and Cambridge Sports of 1868 and 1869; he took both the Mathematical and Natural Science Triposes in the year 1870, being placed fourteenth wrangler in the former and in the first class in the latter; immediately afterwards he was elected to a college fellowship, which he held till 1883. In 1871 Mr. Gurney took orders in the Church of England, and for the next four years worked as curate to Canon Beck in one of the largest and poorest of London parishes, that of Rotherhithe; in the early part of that period he was married at Whitchurch, in Herefordshire, to Louisa, daughter of the Rev. H. Selby Hele, of Grays, Essex, and great-granddaughter of Bishop Horne.

Mr. Gurney's innate love of crystals had been developed under the influence of the Cambridge Professor, William Hallows Miller, during whose illness he later acted for some time as Deputy. Appreciating the difficulties which at that epoch presented themselves to English students, Mr. Gurney wrote a very simple and useful Manual of Crystallography (128 pages), founded on the Tract of Professor Miller and the Lectures of Professor Story-Maskelyne; it was published in 1875 by the Society for Promoting Christian

Knowledge. He was one of the Original Members of the Crystallological Society founded on June 14th, 1876, and was a member of its first Council. At one time he meditated acceptance of an appointment in the Mineral Department of the British Museum, but, notwithstanding the great attractions which work in a mineral collection would have had for him, he did not feel justified, having regard to the interests of his family, in becoming a candidate for a post of which the prospective emoluments must be both uncertain and small.

Instead, therefore, of making research in mineralogy and crystallography his lifework, Mr. Gurney accepted an offer made to him and became a colleague of, and afterwards (1877–94) managing partner with, Mr. Walter Wren in the large establishment which the latter had instituted at Westbourne Park for the training of candidates for the various competitive examinations for posts in the Army and in the Home and Indian Civil Services; there his vast energy, physical and mental, found full employment. His remarkable powers of organization, and the personal influence he was able to bring to bear on young men of ability at a very critical period of their lives, contributed largely to the success of the undertaking. The pupils of that establishment now occupy prominent posts in every part of Greater Britain, and it thus comes about that few tutors have ever been more widely known and respected. During a large part (1876–88) of this period, he officiated as curate of the church of St. Peter in Bayswater.

When the Principalship of the Durham College of Science, Newcastle-upon-Tyne, fell vacant through the resignation of Dr. William Garnett, it was felt that the educational experience, the wide culture and attainments, and the personal character of Mr. Gurney marked him out as the ideal man for that important position. His appointment to the post has been abundantly justified during the ten years which have since elapsed.

He devoted himself to the advancement of the interests of the college in every possible way. Of the thousands of students who have passed through the institution during his tenure of office, many will long remember his kindly advice and ready help. His charm of manner and sweetness of disposition made him everywhere popular; and at distributions of school prizes and public meetings in general in Newcastle and the surrounding district, he was sure of a hearty welcome. He took a leading part in inducing the promoters of the Armstrong Memorial Fund to devote its proceeds to the completion of the college buildings, and he afterwards gave help and encouragement in obtaining further subscriptions. Mr. Gurney provided a remarkable illustration of the well-known fact that the busiest man is the one who is most ready to add to his work and responsibilities; he was the representative of the college on the governing bodies of schools at Newcastle, Rothbury, Hartlepool, and Middlesbrough; he was a co-opted member of both the Newcastle and Northumberland Education Committees; he was Chaplain to the Bishop of Newcastle, and also to the Third

Volunteer Battalion of the Northumberland Fusiliers; he was Warden of the Newcastle Diocesan House of Mercy.

Notwithstanding the great multiplicity of the duties which fell to him as Principal, and the demands made on his time by the professorship of mathematics which he later combined therewith, Mr. Gurney found it possible to give some attention to the development of his old subject, the study of crystals. Impressed with the importance of crystallography both as an independent science and as auxiliary to chemistry, physics, mineralogy, and petrology, he equipped the college with apparatus for the measurement of the angles and for the determination of the symmetry and optical characters of crystals, and arranged that opportunity for the acquisition of a theoretical and practical knowledge of the science should be provided for Newcastle students.

Mr. Gurney received the honorary degree of D.C.L. from the University of Durham; he was a Fellow of the Geological and Physical Societies, and for several years was a member of the Council of the Mineralogical Society.

Whenever it was practicable for him, Mr. Gurney sought complete relaxation and change of thought in travel, spending many of his vacations abroad and availing himself of every opportunity of visiting places of general or geological interest both in Europe and America. With the present writer he spent several happy holidays; on one occasion journeying to Moscow, Nijni Novgorod, and down the Volga to Kazan, afterwards making an excursion with other members of the International Geological Congress to various noteworthy places in Finland; a brief account of the latter he gave in his "Notes on the Geology of Finland." He was an ideal companion; full of energy and enthusiasm; of infinite patience, good temper, and cheerfulness; indeed, to see his pleasant face and hear his hearty laugh was almost a holiday in itself. Only a few short weeks ago he proposed that they should again spend a few weeks together, this time at Arolla in Switzerland, where he was to go with two of his daughters, but the writer was unable to leave London. Soon afterwards came the startling news of his death. With only a walking-stick in his hand, he had started off alone at 8 a.m. on August 13th, not saying, probably not knowing, how far he was likely to go. Night came and he did not return. Search was immediately begun, and by dusk the next day his footmarks had been discovered on an *arête* of the Gysa, a southern spur of Mount Roussette; there they ceased. Soon after dawn on the following morning his body was discovered several hundred feet below; his watch had stopped at nearly 12. Notwithstanding the caution and carefulness which were ever prominent features in his own character, and were strongly impressed by him on others, he had doubtless been gradually led on by the beauty of the view to climb higher and higher, and had eventually and unexpectedly found himself in a place where a slip was easy and would mean instant death.

His loss will long be felt far and wide, more especially in the